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Aarkrog, A.; Lippert, Jørgen Emil

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INIS Descriptors

[0] BACKGROUND RADIATION
DENMARK
DIET
ENVIRONMENT
FOOD
FOOD CHAINS
GAMMA RADIATION
GLOBAL FALLOUT
PLANTS
RADIOACTIVITY
RADIOECOLOGICAL CONCENTRATION
SEAWATER
SOILS

[1] AIR
BONE TISSUES
FRESH WATER
GROUND WATER
RAIN WATER
STRONTIUM 90

[2] CESIUM 137
WHOLE-BODY COUNTING

UDC 614.73 (489)

Environmental Radioactivity in Denmark in 1975

by

A. Aarkrog and J. Lippert

Research Establishment Risø
Health Physics Department

Abstract

The present report deals with the measurement of fall-out radioactivity in Denmark in 1975. Strontium-90 was determined in samples from all over the country of precipitation, soil, ground water, stream and lake water, sea water, grass, dried milk, fresh milk, grain, bread, potatoes, vegetables, fruit, total diet, and human bone. Furthermore, ^{90}Sr was determined in local samples of air, rain water, grass, sea plants, fish, and meat. Caesium-137 was determined in soil, sea water, milk, grain products, potatoes, vegetables, fruit, total diet, fish, and meat. It was also measured by wholebody-counting of a control group at Risø. Estimates of the mean contents of radiostrontium and radiocaesium in the human diet in Denmark during 1975 are given. The γ-background was measured regularly at locations around Risø, and at ten of the State experimental farms. Finally the report includes routine surveys of environmental samples from the Risø area.

Statens trykningskontor
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ABBREVIATIONS AND UNITS

FP	fission products
fCi	femtocurie 10^{-15} Ci
pCi	picocurie, 10^{-12} Ci, μμCi
nCi	nanocurie, 10^{-9} Ci, mμCi
mCi	millicurie, 10^{-3} Ci
MPC	maximum permissible concentration
c/min	counts per minute
d/min	disintegrations per minute
c/h	counts per hour
μR	micro-roentgen, 10^{-6} roentgen
S. U.	pCi ^{90}Sr/g Ca
O. R.	observed ratio
M. U.	pCi ^{137}Cs/g K
V	vertebrae
m	male
f	female
nSr	natural (stable) Sr
eqv. μg U	equivalents μg uranium: activity as from 1 μg U (~90 d/h)
eqv. mg KCl	equivalents mg KCl: activity as from 1 mg KCl (~0.88 d/min)
S. D.	standard deviation: $\sqrt{\frac{\Sigma(\bar{x}-x_i)^2}{(n-1)}}$
S. E.	standard error: $\sqrt{\frac{\Sigma(\bar{x}-x_i)^2}{n(n-1)}}$
U. C. L.	upper control level
L. C. L.	lower control level
Δ	one standard deviation due to counting
S. S. D.	sum of squares of deviation: $\Sigma(\bar{x}-x_i)^2$
f	degrees of freedom
s^2	variance
v^2	ratio between the variance in question and the residual variance
P	probability fractile of the distribution in question
η	coefficient of variation, relative standard deviation
anova	analysis of variance
A	relative standard deviation 20-33%
B	relative standard deviation 〉 33%, such results are not considered significantly different from zero activity
B. D. L.	below detection limit

Samples:

H:	sea water
J:	soil
L:	air
B:	bed soil
Å:	eel
PG:	grass
PH:	sea plants
D:	drain water
S:	waste water
R:	precipitation
M:	milk

1. INTRODUCTION

1.1.

The present report is the nineteenth of a series of periodic reports (cf.ref. 1) dealing with measurements of radioactivity in Denmark. The programme is unchanged as compared with 1974.

1.2.

The methods of radiochemical analysis[2-4] and the statistical treatment of the results[5] are still based on the principles established in previous reports[1].

1.3.

The report does not include detailed tables of the total β-measurements from the environmental control of the Risø site. These tables are available in the form of microcards at the Risø library.

1.4.

The report contains no information on sample collection and analysis except in the cases where these procedures have been altered.

1.5.

In 1975 the personnel of the Environmental Control Section of the Health Physics Department consisted of one chemist, ten laboratory technicians, two sample collecters, and two laboratory assistants. The Section for Electronics Development continued to give assistance in the maintenance of the counting equipment and in the interpretation of the γ-spectra. The program (cf. 2) used in the calculations of ^{90}Sr and the γ-analysis, as well as the program for data treatment, were developed by this section.

1.6.

The composition of the average Danish diet used in this report is identical with that proposed in 1962 by Professor E. Hoff-Jørgensen, Ph. D.

2. ORGANIZATION AND FACILITIES[1, 6, 7, 8]

Four Ge(Li)-detectors, each connected to a 1024-channel analyzer, are available. An 8 inch NaI(TL)-detector used for whole-body measurements and four detectors for alpha spectrometry are connected to a 1024-channel analyzer and a 256-channel analyzer respectively.

A computer program, STATDATA[16], is available for the treatment of the results of this report (and the results of several other projects. The program checks and stores the data, produces lists, tables and plots and calls separate programs for analysis of variance and regression, etc. The principle for registering the data is the assignment of 6 parameters to each result or set of multiple results. These parameters are:

Isotope (or code for γ-background, etc.)
Sampling date
Sample type
Sampling location
Quality of measurement (relative standard deviation)
Unit of results

followed by:

Number of results
Results.

To date approximately 33000 sets of results have been registered covering the period from 1957. However, a number of results still remains unregistered.

3. ENVIRONMENTAL MONITORING AT RISØ IN 1975

3.1. Gross β-Activity

3.1.1. Sea Water

Fig. 3.1.1.1 shows the sample locations in Roskilde Fjord. Fig. 3.1.1.2 shows the control chart for H I. The yearly mean for H I in 1975 was 55 eqv. mg KCl/2.5 g (in 1974: 53), for H III-VI: 54 eqv. mg KCl/2.5 g (in 1974: 53) and for H VII-X: 54 eqv. mg KCl/2.5 g (in 1974: 53). Fig. 3.1.1.3 shows the mean levels of radioactivity in sea salt since 1957.

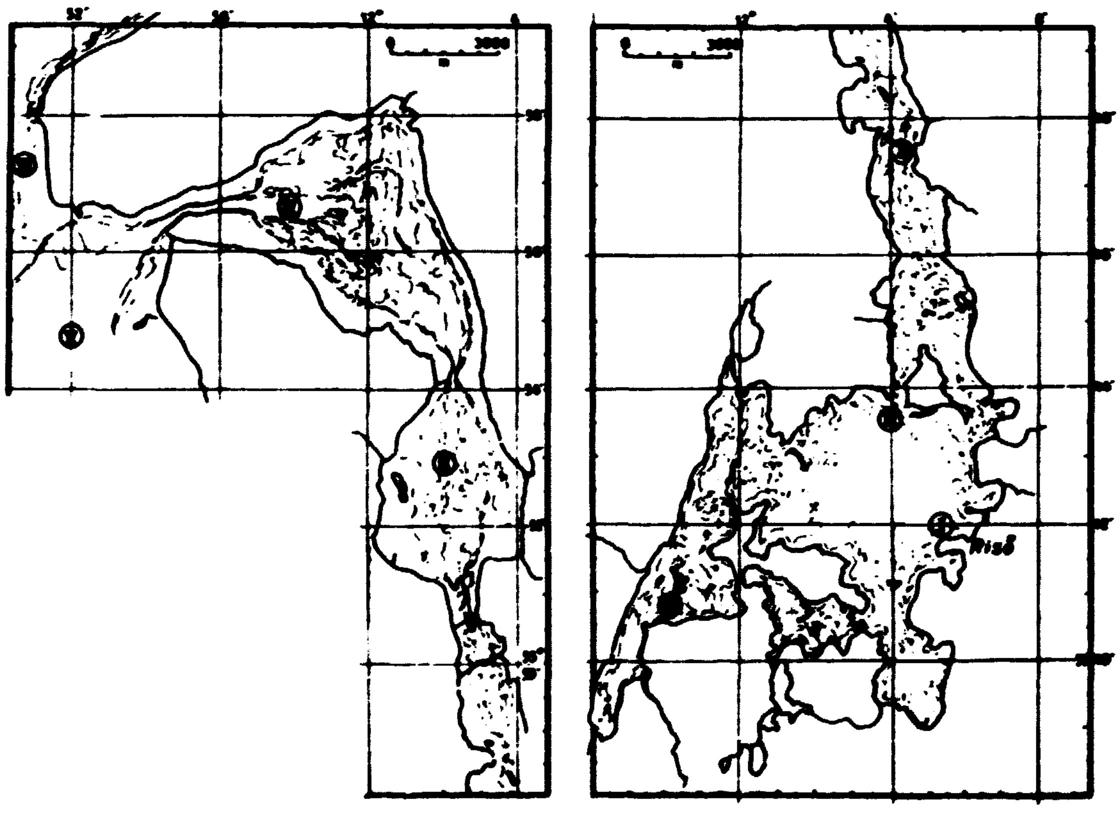

Fig. 3.1.1.1. Roskilde Fjord.

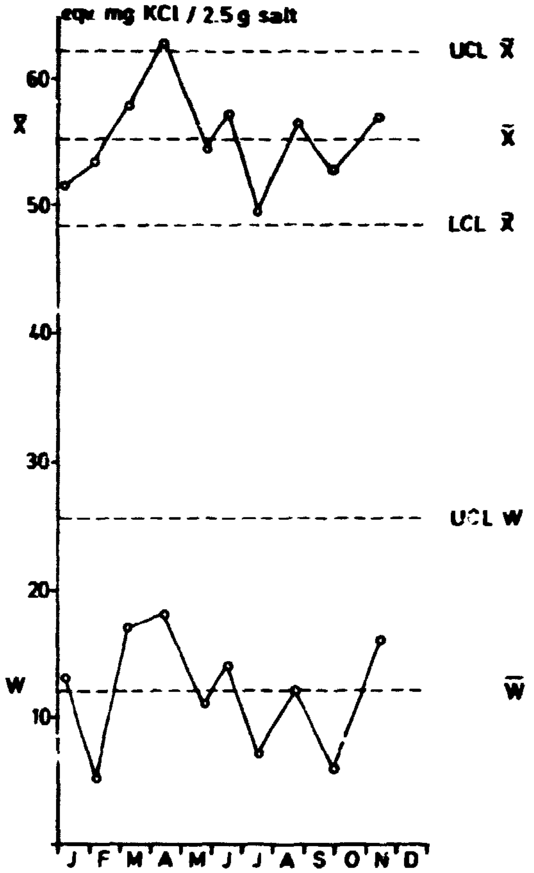

Fig. 3.1.1.2. Control chart for HI, 1975.

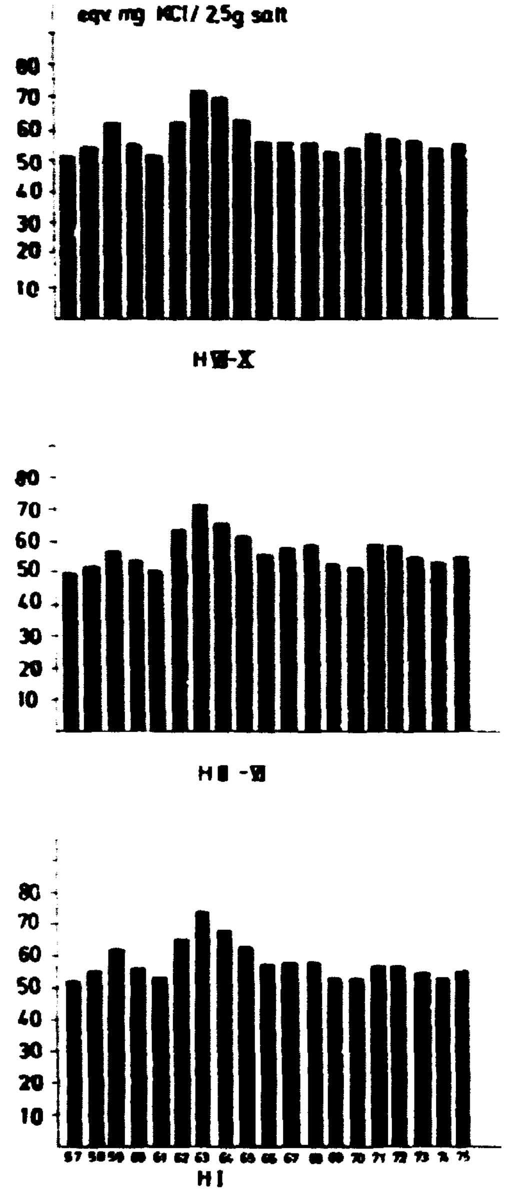

Fig. 3.1.1.3. Mean radioactivity in sea water 1957-75.

3.1.2. Soil

No soil samples from the environment of Risø were measured for total β-activity in 1975.

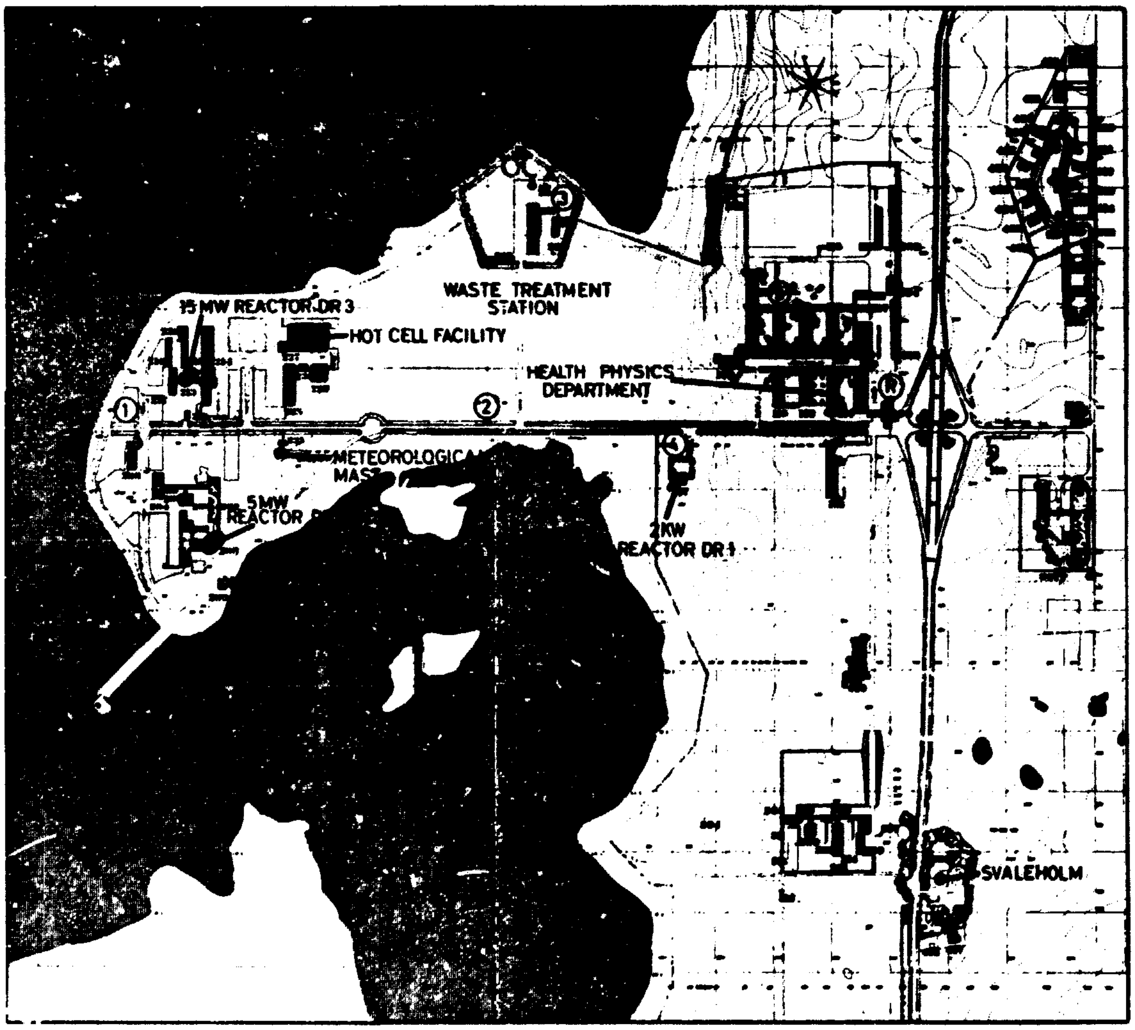

Fig. 3.1.2.1. The Risø Research Establishment.

3.1.3. Air

Fig. 3.1.3.1 shows the diagram for FP activity in air samples in 1975. The mean value for the year was 0.08 eqv. mg KCl/m^3 as compared with 0.24 eqv. mg KCl/m^3 in 1974.

Fig. 3.1.3.2 shows the mean FP levels in air since 1957.

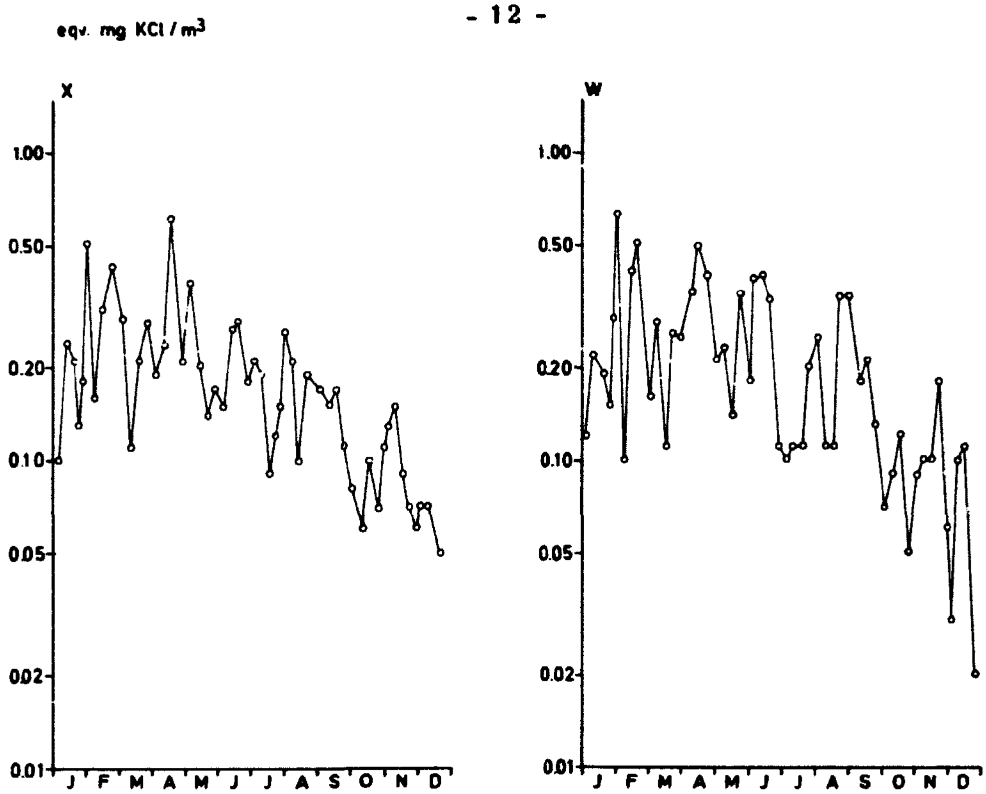

Fig. 3.1.3.1. Control chart for LF, 1975.

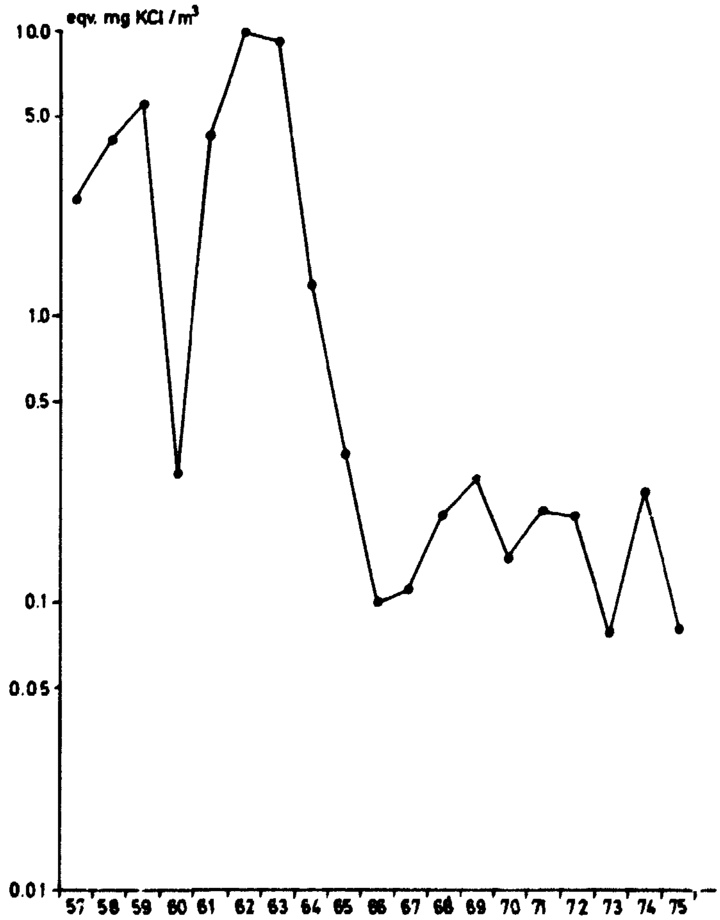

Fig. 3.1.3.2. Mean radioactivity in air, 1957-75.

3.1.4. Bed Soil from the Fjord

The mean activity in bed soil B I was 143.5 eqv. mg KCl/3.0 g ash in 1975 as compared with 129 eqv. mg KCl/3.0 g in 1974. Fig. 3.1.4.1 shows the mean levels for B I since 1957 (cf. also 3.4).

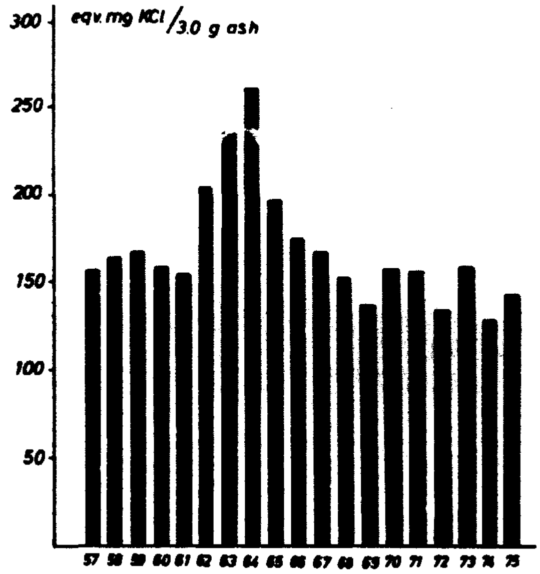

Fig. 3.1.4.1. Mean radioactivity in bed soil, 1957-75.

3.1.5. Fish

No fish samples from Roskilde Fjord were measured for total β-activity in 1975.

3.1.6. Grass

The mean values were in 1975 for PG I: 14 eqv. mg KCl/0.1 g grass ash (in 1974: 11), for PG II-III: 15 eqv. mg KCl/0.1 g (in 1974: 11) and for PG IV-V: 6 eqv. mg KCl/0.1 g (in 1974: 13). Fig. 3.1.6.1 shows the mean activities in grass ash since 1957.

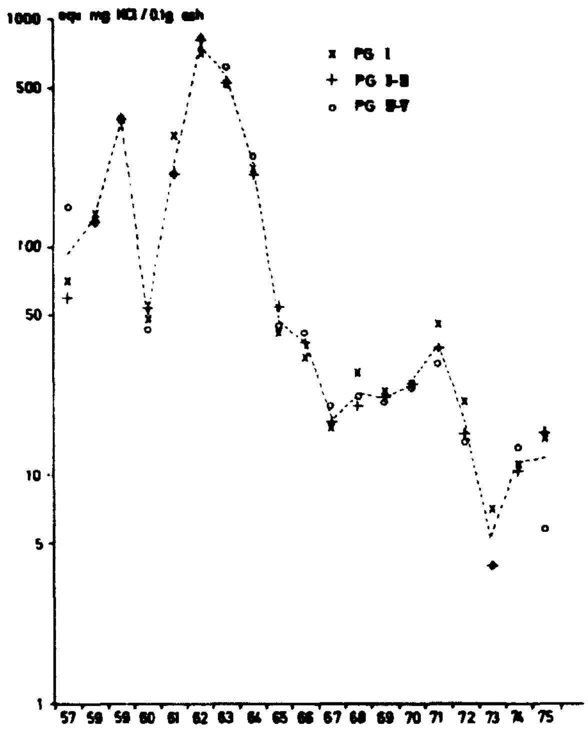

Fig. 3.1.6.1. Mean FP-radioactivity in grass ash, 1957-75.

3.1.7. Sea Plants

The mean FP level in 1975 in Fucus vesicolosus (PH I) was 0 eqv. mg KCl/0.1 g ash (4 in 1974). In Zostera marina (PH III-IX) we found 0 eqv. mg KCl/0.1 g ash in 1975 (5 in 1974).

3.1.8. Fresh Water

Fig. 3.1.8.1 shows the control chart for S (cf. fig. 3.1.2.1). The yearly means for D I, D II, D IV, and S in 1975 were 17 eqv. mg KCl/l (1974: 40), 14 eqv. mg KCl/l (1974: 19), 55 eqv. mg KCl/l (1974: 43), and 35 eqv. mg KCl/l (1974: 31) respectively. Fig. 3.1.8.2 shows the activity in drainage water (D) and sewage water (S).

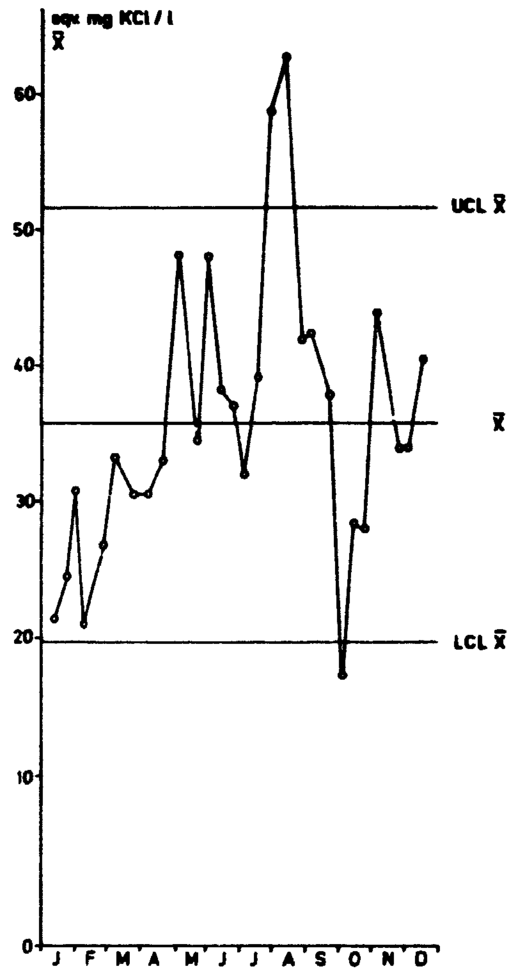

Fig. 3.1.8.1. Control chart for sewage water (S), 1975.

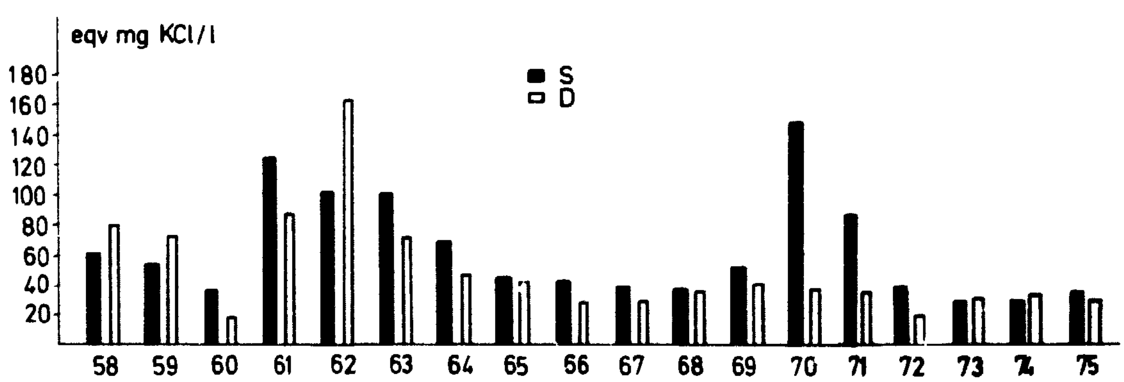

Fig. 3.1.8.2. Mean radioactivity in fresh water, 1958-75.

3.1.9. Rain Water

Figs. 3.1.9.1 and 3.1.9.2 show the specific FP level in and the total fall-out from rain water collected daily at Risø in 1975. The total fall-out in 1975 was measured at $0.008 \cdot 10^6$ eqv. mg KCl/m^2, and the annual mean concentration in rain water at Risø was 18 eqv. mg KCl/l. In 1974 the corresponding figures were $0.028 \cdot 10^6$ and 49 respectively.

Fig. 3.1.9.3 shows the specific activity in rain water since 1957.

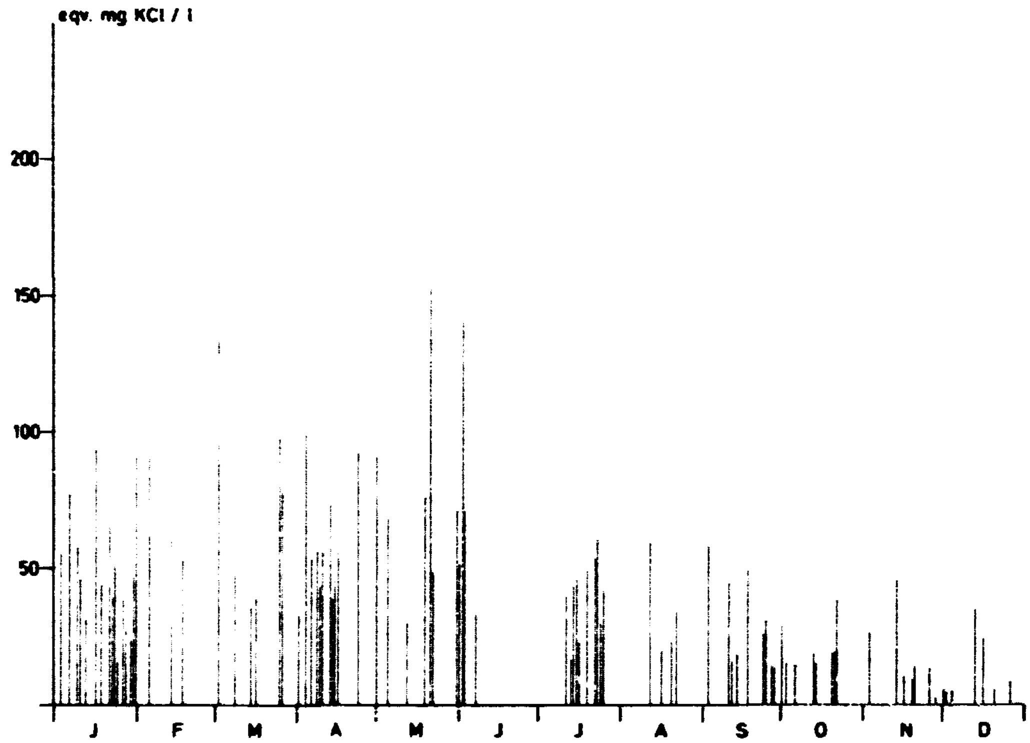

Fig. 3.1.9.1. Concentration of β-activity in precipitation in 1975.

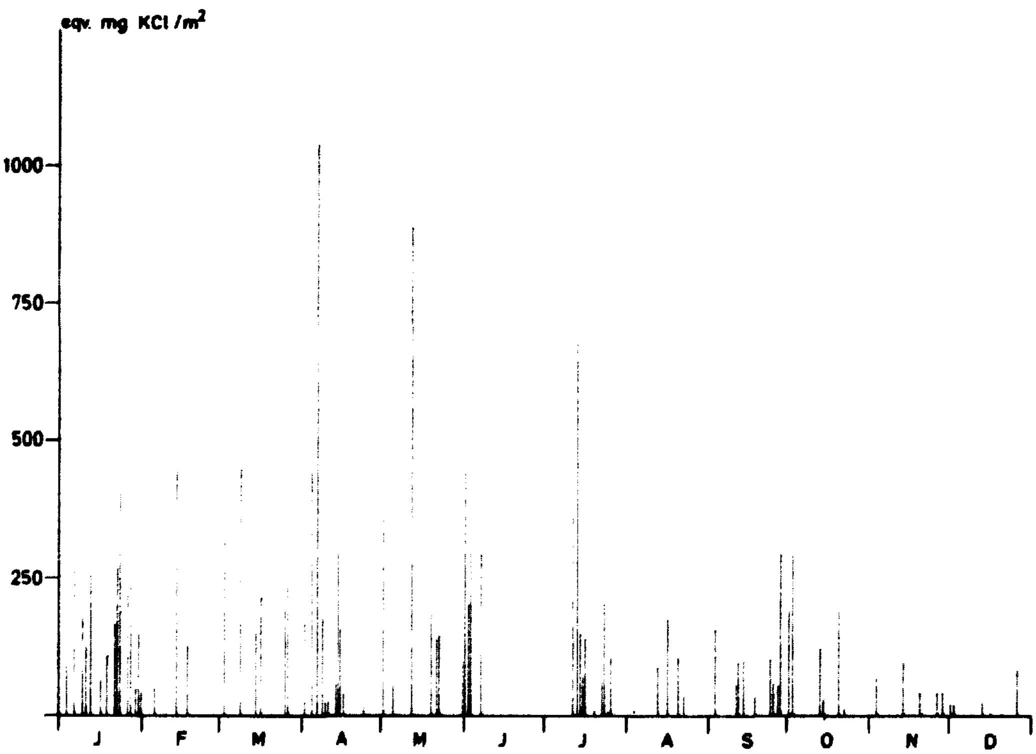

Fig. 3.1.9.2. Total fall-out from precipitation in 1975.

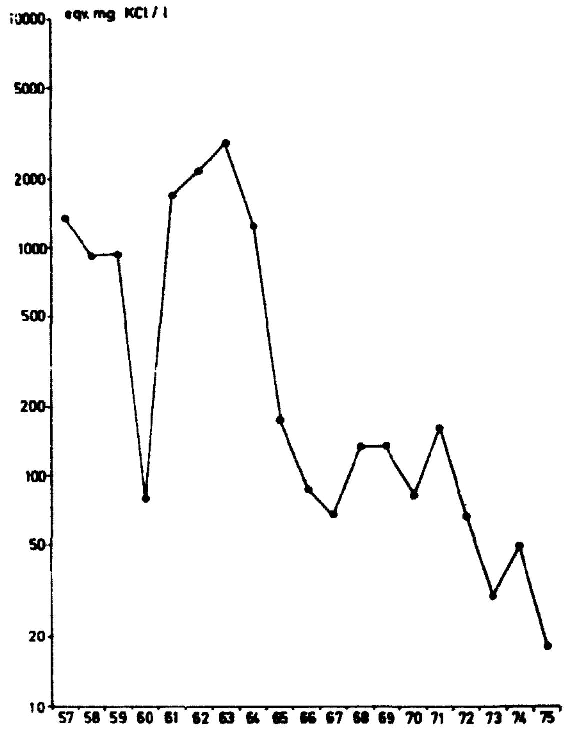

Fig. 3.1.9.3. Specific activity in precipitation, 1957-75.

3.2. Radiochemical β-Analysis

3.2.1. Air

The "big air sampler" described in Risø Report No. 23[1)] has a shunt through which the air volume is determined. As in the four previous years, both the shunt filter (I) and aliquots cut out from the main filter (II) were analysed to see whether activity levels were identical in the two filters. As I/II = 1.09 $\pm$ 0.06 (1 SE), we still concluded that the two filters showed the same levels. The mean air activity level for 1975 is reported as the mean of the glass-fibre filter collection and the daily paper filter sampling: 0.90 $\pm$ 0.05 pCi $^{90}Sr/10^3$ m^3, i.e. 0.6 times the 1974 level. The mean peak activity of the three collections in 1975 was measured in April to be 1.7 pCi $^{90}Sr/10^3$ m^3.

Fig. 3.2.1.1 shows the ^{90}Sr levels in air since 1957.

Table 3.2.1

Strontium-90 in air collected at Risø in 1975
pCi $^{90}Sr/10^3m^3$

Month	Daily air filters	Monthly air filters (glass-fibre filters)	
	Paper	I	II
Jan.	0.97	1.00	0.74
Feb.	1.03	1.49	0.93
Mar.	1.21	1.70	1.69
Apr.	1.26	1.89	1.97
May	1.17	1.60	1.60
June	1.11	1.54	1.46
July	1.07	1.01	1.05
Aug.	0.63	0.57	0.63
Sep.	0.45	0.32	0.34
Oct.	0.32	0.27	0.24
Nov.	0.27	0.15	0.14
Dec.	0.27	0.17	0.16
1975	0.81	0.98	0.91

I: are the normally used shunt filters.

II: are aliquots cut out from the main filters also used for ^{137}Cs determination (cf. table 3.3.1).

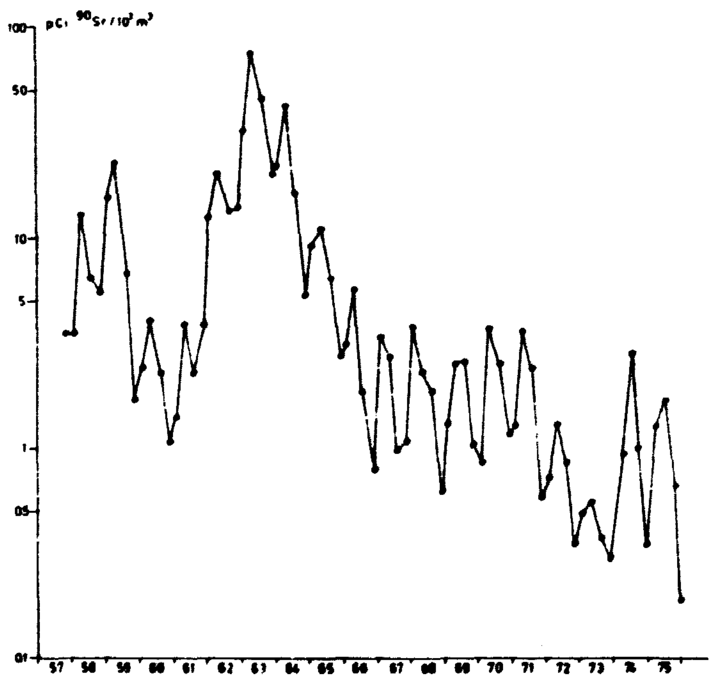

Fig. 3.2.1.1. Quarterly ^{90}Sr levels in air, 1957-75.

3.2.2. Grass

Table 3.2.2 shows the ^{90}Sr content in grass ash from Zealand in 1975. The mean ^{90}Sr activity was 2.6 pCi $^{90}Sr/g$ ash or 44 S.U. as compared with 2.8 pCi/g ash or 47 S.U. in 1974, i.e. the 1975 level was approx. equal to the 1974 level. Fig. 3.2.2.1 shows the ^{90}Sr concentration in grass since 1957 compared with the predicted levels (cf. Appendix C).

Table 3.2.2

Strontium-90 in grass from Zealand, 1975

	pCi $^{90}Sr/g$ ash	pCi $^{90}Sr/g$ Ca
Jan.-Mar.	2.77	61
Apr.-June	2.37	49
July-Sep.	2.93	38
Oct.-Dec.	2.15	28
Mean	2.55	44

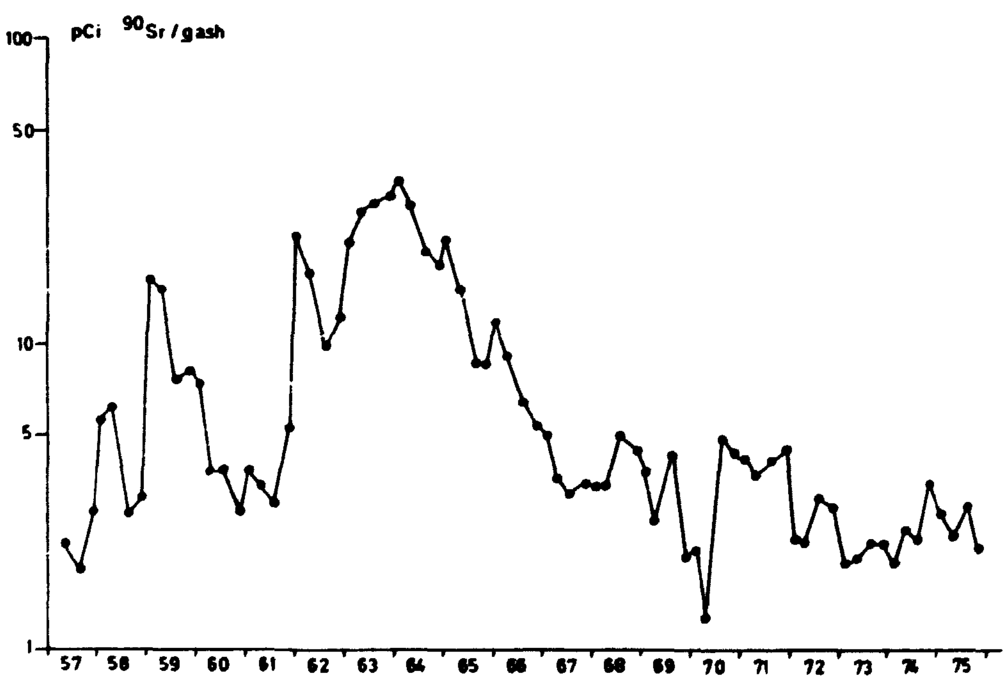

Fig. 3.2.2.1. Quarterly ^{90}Sr levels in grass, 1957-75.

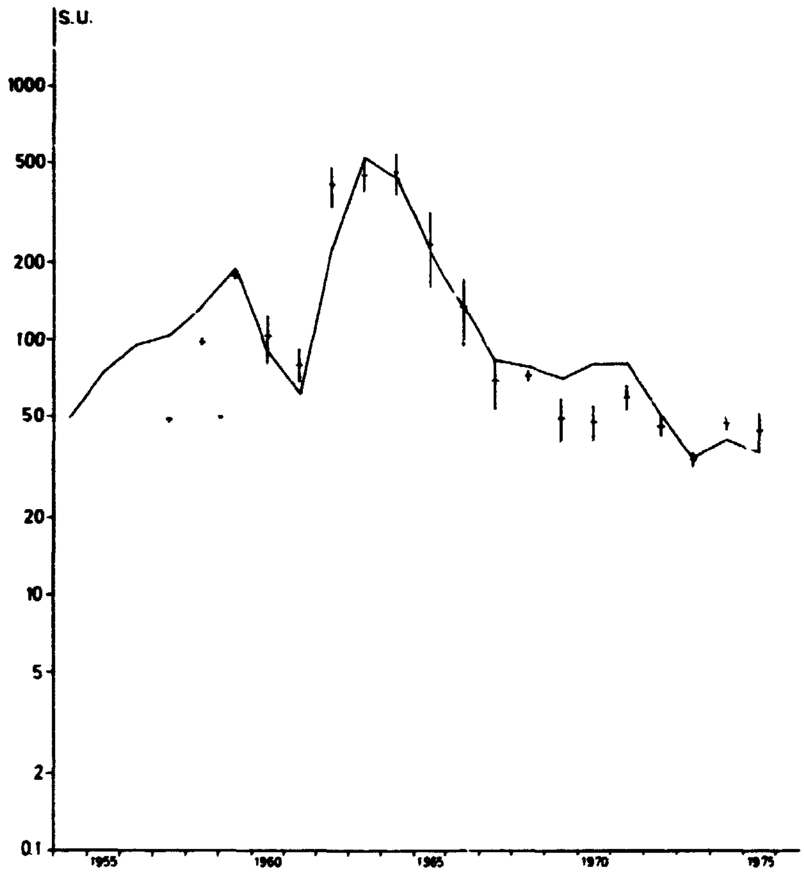

Fig. 3.2.2.2. A comparison between observed (± 1 S.E.) and calculated (curve, cf. appendix C) S.U. levels in grass from Zealand.

3.2.3. Sea Plants

Fig. 3.2.3 shows the S.U. levels in sea plants since 1959 and table 3.2.3 the results for 1975. The level in Fucus vesicolosus was 13.8 pCi ^{90}Sr/g Ca, and in Zostera marina 4.2 pCi ^{90}Sr/g Ca.

Table 3.2.3

Strontium-90 in sea plants from Roskilde Fjord in 1975

Location		Species	pCi ^{90}Sr/g Ca	pCi ^{90}Sr/g ash
June	I	Fucus vesicolosus	12.7	1.04
July	III	Zostera marina	5.2	0.28
June	IX	Zostera marina	4.3	0.22
Nov.	I	Fucus vesicolosus	14.9	1.39
Dec.	III	Zostera marina	5.1	0.24
Nov.	IX	Zostera marina	2.3	0.45

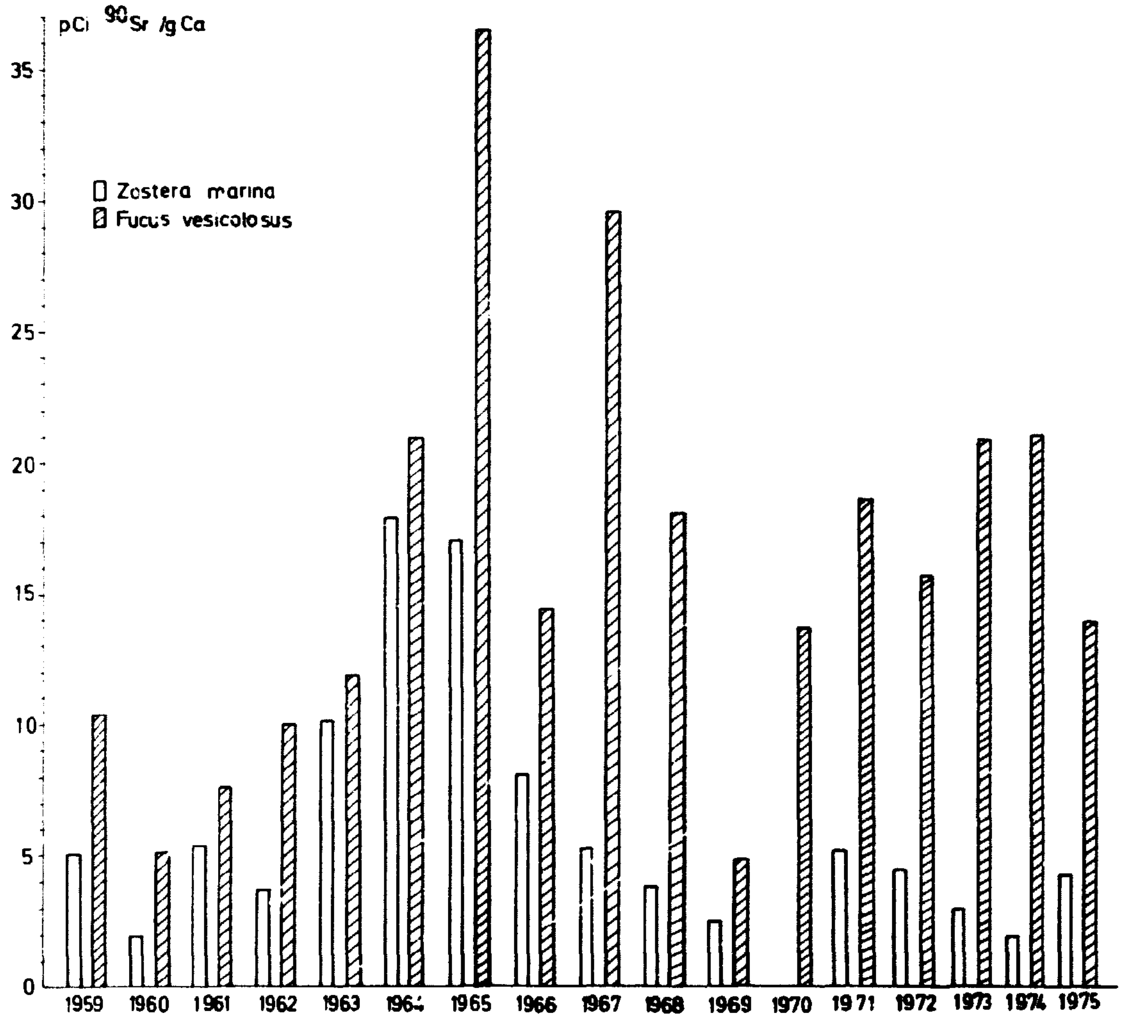

Fig. 3.2.3. Strontium-90 in sea plants from Roskilde Fjord, 1959-75.

3.2.4. Rain Water

Table 3.2.4.1 shows the quarterly radiostrontium level in rain water collected at Risø in 1975. The total ^{90}Sr fall-out in 1975 was 0.27 mCi ^{90}Sr/km^2 (477 mm precipitation), and the mean concentration in the rain water was 0.56 pCi ^{90}Sr/l. In 1974 we measured 0.42 mCi ^{90}Sr/km^2 (555 mm precipitation) and 0.77 pCi ^{90}Sr/l, i.e. the 1975 ^{90}Sr levels were 0.6 times the 1974 figures.

Fig. 3.2.4.1 shows the ^{90}Sr levels in rain water since 1959.

At five sampling locations (1-5) in zone I (cf. fig. 3.1.2.1) ion-exchange columns were used to collect monthly samples of precipitation together with the bottle collectors. These columns have been described earlier (Risø Report No. 41[1]) and are similar to those used in the U.S.A. by HASL[4]. Our intention was to compare the efficiency of the ion-exchange columns to

Table 3.2.4.1

Strontium-90 in rain water collected in rain bottles at Risø in 1975 (sampling area 0.236 m²)

Month	mm	pCi ^{90}Sr/l	mCi ^{90}Sr/km^2
Jan.-Mar.	106	0.85	0.091
Apr.-June	107	0.95	0.101
July-Sep.	147	0.34	0.050
Oct.-Dec.	117	0.20	0.024
1975	Σ 477	$\bar{x}$ 0.56	Σ 0.266

$$\bar{x}\ \text{pCi/l} = \frac{\Sigma\ \text{mCi/km}^2 \cdot 10^3}{\Sigma\ \text{mm}}$$

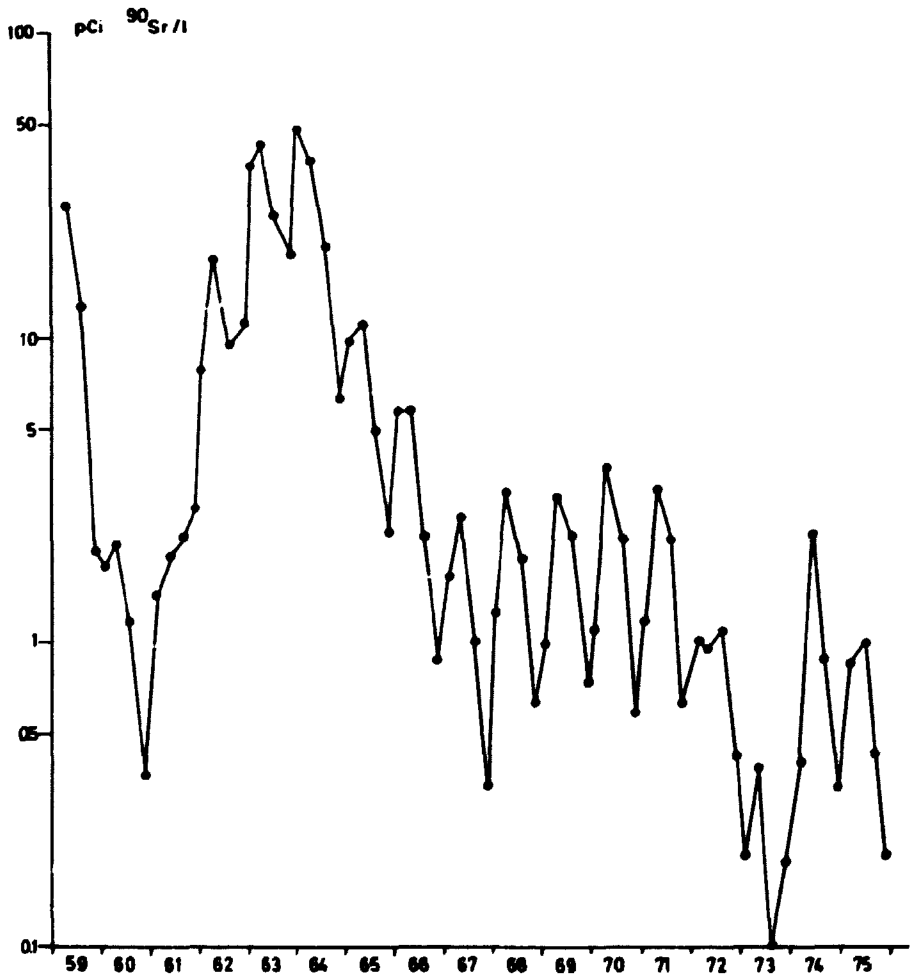

Fig. 3.2.4.1. Quarterly ^{90}Sr levels in precipitation, 1959-75.

Table 3.2.4.2

Strontium-90 in rain water collected in ion-exchange column collectors at Risø in 1975 (sampling area 0.325 m²)

Month	mm	pCi ^{90}Sr/l	mCi ^{90}Sr/km^2
Jan. - Mar.	91	0.47	0.042
Apr. - June	106	0.74	0.079
July - Sep.	110	0.38	0.041
Oct. - Dec.	100	0.14	0.014
1975	Σ 407	$\bar{x}$ 0.43	Σ 0.176

collect fall-out with that of the rain bottles. Table 3.2.4.2 shows the results. The total amount of ^{90}Sr fall-out in 1975 measured by the 2 systems was: 0.27 and 0.18 mCi ^{90}Sr/km^2 respectively.

Figures 3.2.4.2 and 3.2.4.3 show comparisons between the different sampling systems for ^{90}Sr in precipitation. It appears that the specific activity in pCi ^{90}Sr/l is not systematically different for the 3 sampling systems. We may further conclude that the rain bottles and the ion-exchange collectors at Risø show no significant difference as regards efficiency of collecting ^{90}Sr from precipitation.

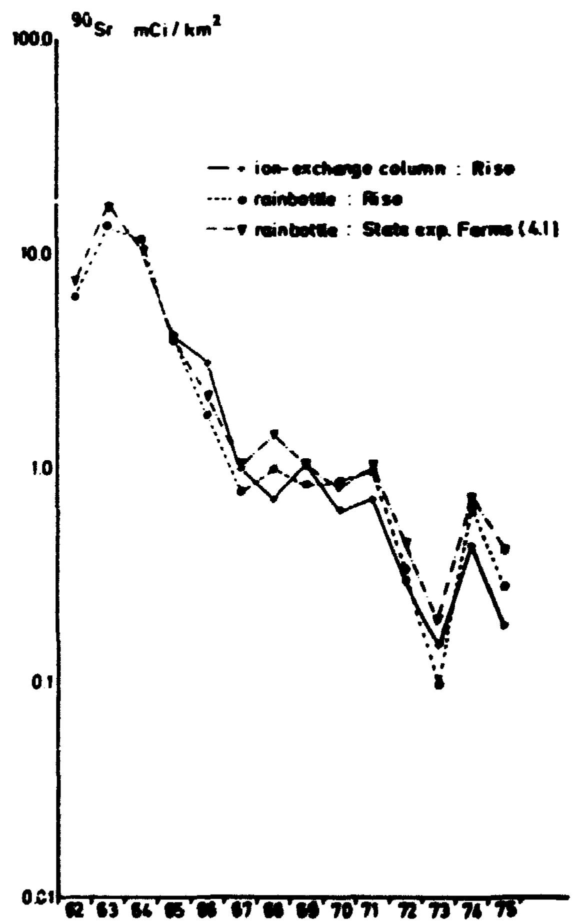

Fig. 3.2.4.2. Strontium-90 fall-out measured by 3 different sampling systems 1962-75.

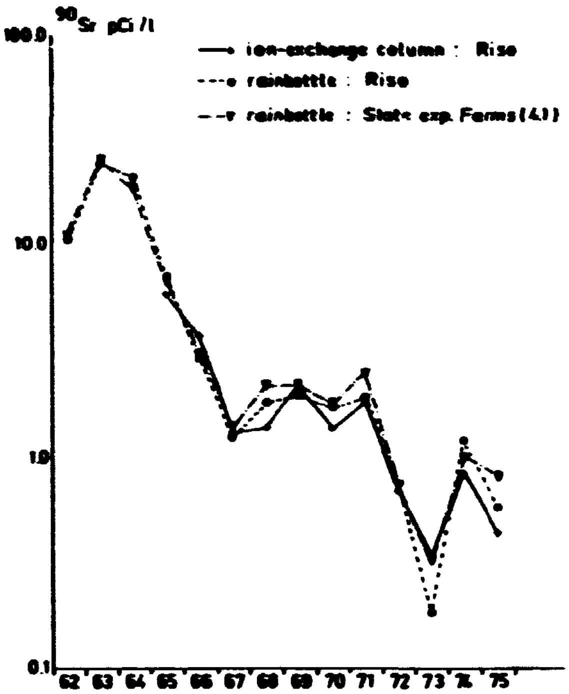

Fig. 3.2.4.3. The specific ^{90}Sr activity in precipitation collected by 3 different sampling systems 1962-75.

3.2.5. Milk from a Farm near Risø

Table 3.2.5 shows the radiostrontium and ^{137}Cs contents in milk collected in 1975 from a farm near Risø. The mean level was 2.3 S.U. as compared with 2.2 S.U. in 1974. Figure 3.2.5 shows the ^{90}Sr levels in "Risø" milk since 1959. The Caesium-137 mean level was 2.8 pCi/l i.e. equal to the level in 1974.

Table 3.2.5

Strontium-90 and Caesium-137 in milk from Risø* in 1975

Month	pCi ^{90}Sr/g Ca	pCi ^{137}Cs/g K	pCi ^{137}Cs/l
Jan. - Mar.	2.95	1.37 A	2.35 A
Apr. - June	2.36	1.63 A	2.88 A
July - Sep.	1.97	2.29	3.89
Oct. - Dec.	2.00	1.15 B	1.88 B
1975	2.32	1.61	2.75

*The milk was collected from the milk-producing farm nearest to Risø

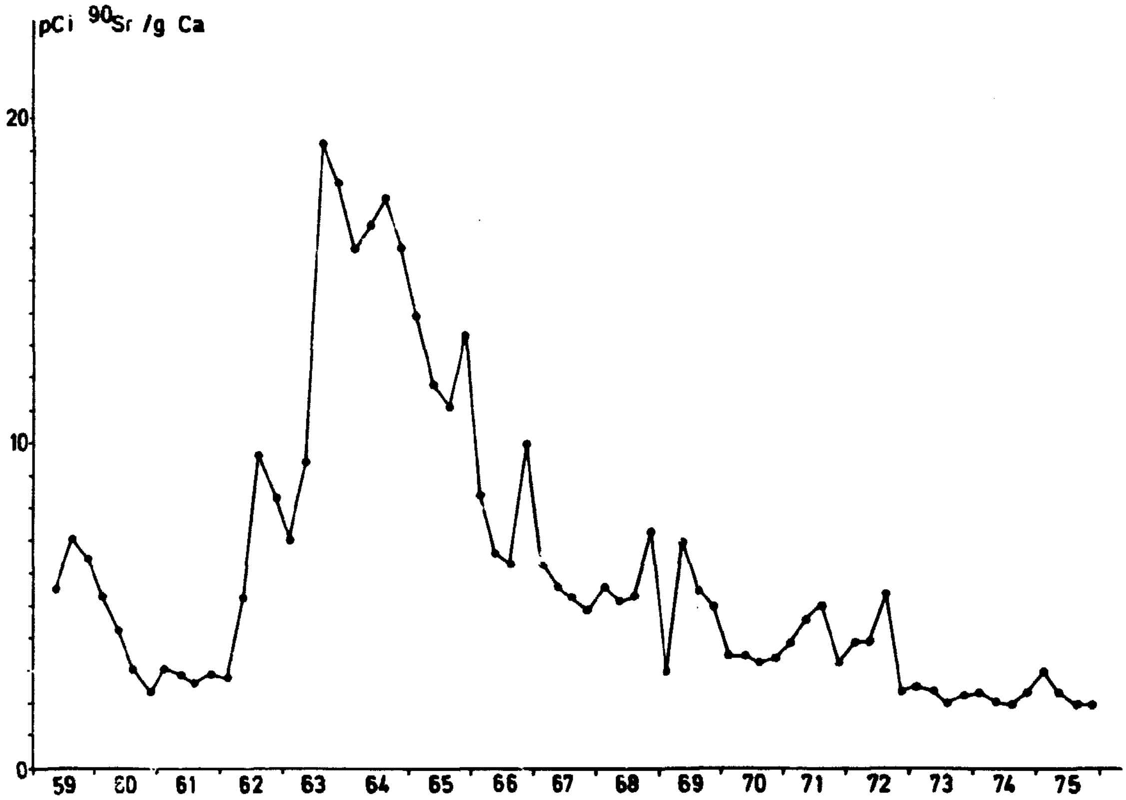

Fig. 3.2.5. Quarterly ^{90}Sr levels in milk from the Risø neighbourhood 1959-75.

3.3. γ-Spectroscopy of Air Samples

As in 1962-1974, samples of air were collected twice a week by means of the air sampler described in Risø Report No. 23[1]. The filters were measured on a 30 cm^3 Ge(Li) detector[8]. Table 3.3.1 shows the monthly means of the ^{137}Cs determinations. The peak value was observed in April (cf. also ^{90}Sr in air, table 3.2.1). The mean level in 1975 was 0.7 times the 1974 mean. The ^{137}Cs/^{90}Sr ratio in air filters was 1.4 in 1975, i.e. the same as 1974.

Table 3.3.1

Caesium-137 in glass-fibre air filters collected twice a week at Risø in 1975

Month	pCi $^{137}Cs/10^3m^3$
Jan.	1.05±0.11
Feb.	1.39±0.34
Mar.	2.44±0.39
Apr.	2.80±0.46
May	2.20±0.37
June	2.08±0.20
July	1.55±0.17
Aug.	0.76±0.10
Sep.	0.50±0.07
Oct.	0.35±0.06
Nov.	0.25±0.04
Dec.	0.22±0.03
1975	1.30

The error term is the S.E. of the mean of the activity found in 8 or 9 filters collected during a month.

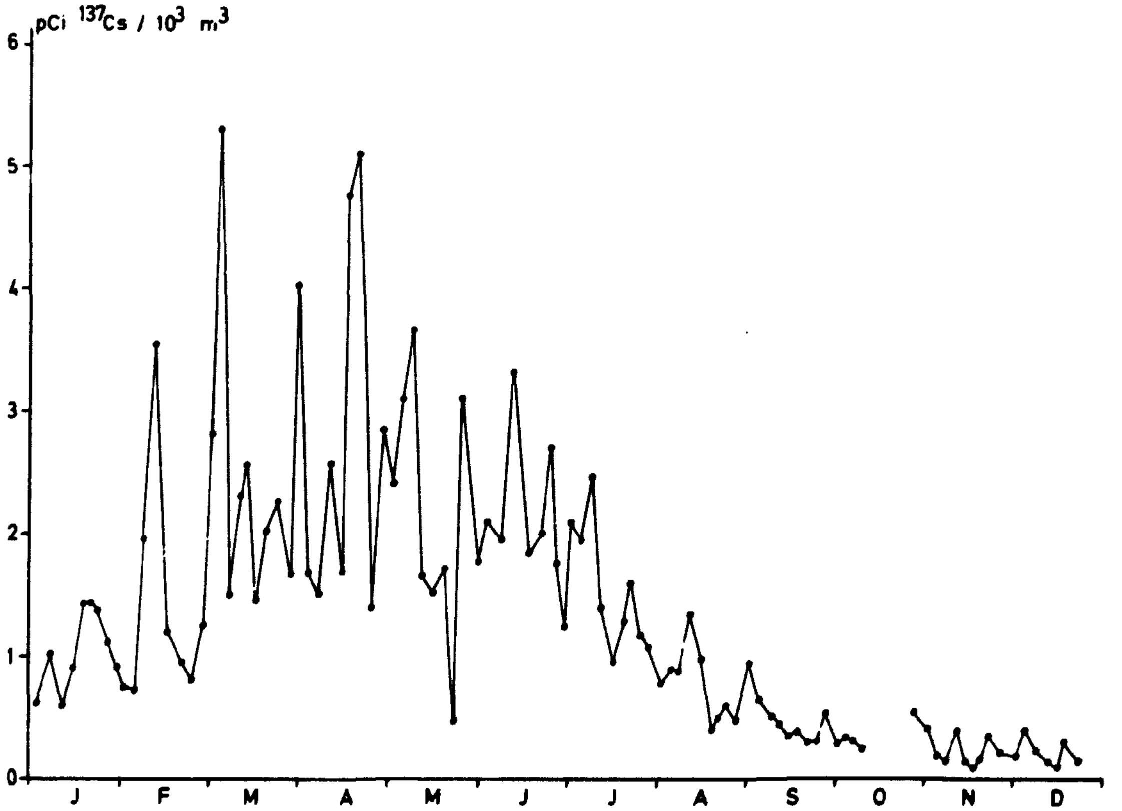

Fig. 3.3.1. Caesium-137 in ground level air at Risø in 1975.

3.4. γ-Spectroscopy of Bed Soil Samples from Roskilde Fjord

North of the outlet from the Waste Treatment Station (fig. 3.1.2.1), bed soil samples have been collected with a HAPS sampler. Cores down to a depth of approx. 15 cm were analysed by Ge(γ) spectrometry. Table 3.4.1 shows the results which are equal to those in 1973.

Table 3.4.1

Caesium-137 in bed soil collected in Roskilde Fjord in 1975 (HAPS) (145 cm^2)

Date	Depth in cm	pCi $^{137}Cs/kg$	mCi $^{137}Cs/km^2$
30/1		277	36
2/4		403	50
5/5	0-12	177	25
4/6	0-13	106	15
14/7	0-15	214	34
9/9	0-13	184	24
24/10	0-15	218	32
17/12		162	21
1975		218	30
SD		90	11
SE		32	4

4. RADIOSTRONTIUM AND RADIOCAESIUM IN PRECIPITATION, SOIL, GROUND-, STREAM- AND LAKE-WATER IN DENMARK IN 1975

4.1. Strontium-90 in Precipitation

Samples of rain water were collected in 1975 from the ten State experimental farms (cf. fig. 4.1.1) in accordance with the principles laid down in Risø Report No. 63, p. 51[1].

Table 4.1.1 shows the results of the ^{90}Sr determinations and tables 4.1.2 and 4.1.3 the analysis of variance of the results. The variation with time was highly significant (P > 99.95%). The maximum concentration in

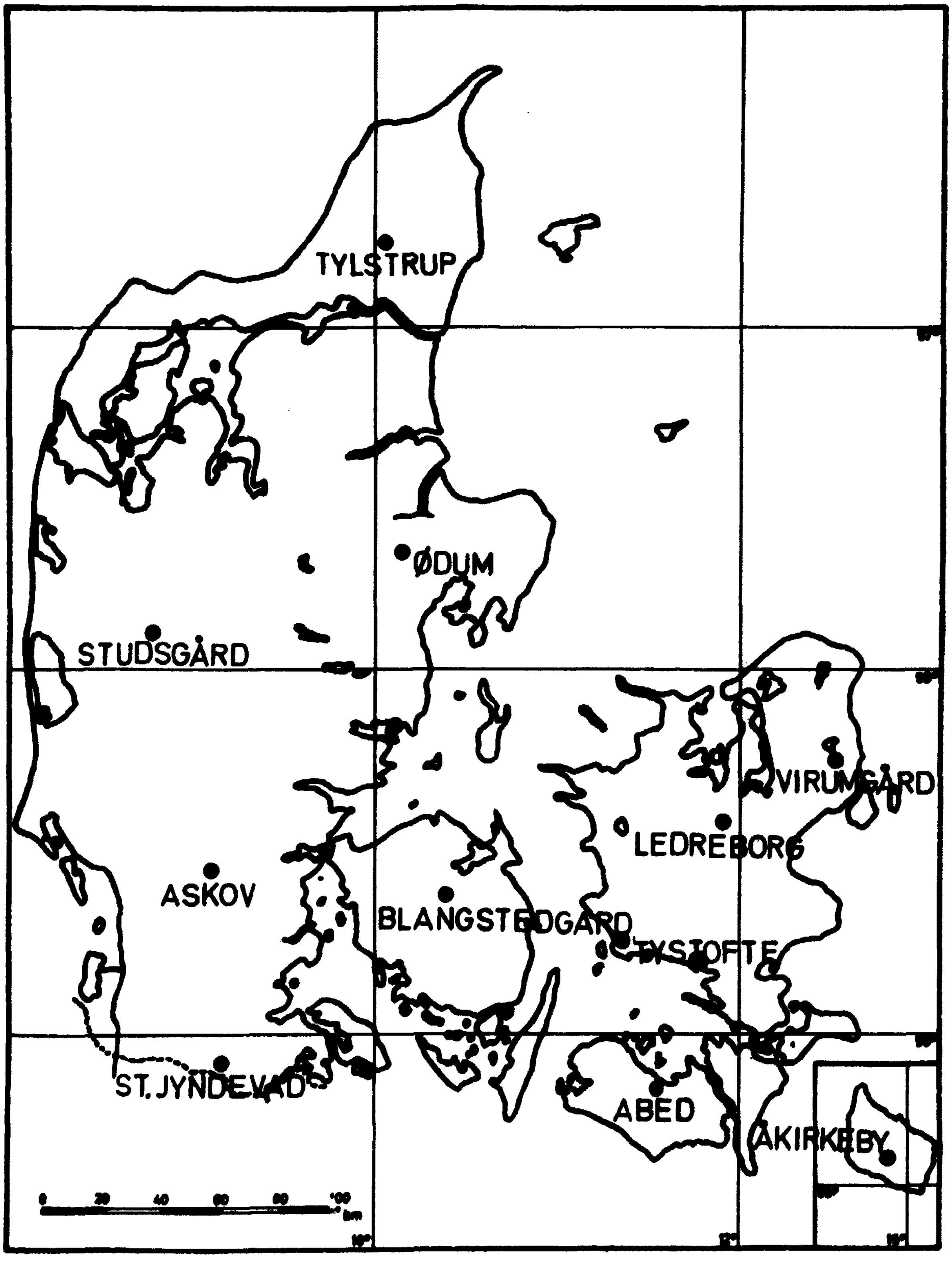

Fig. 4.1.1. State experimental farms in Denmark.

precipitation occurred in May-June, when the mean content in precipitation was 3.18 pCi ^{90}Sr/l (cf. also the air measurements in 3.2.1) while the maximum fall-out rate occurred in March-April 0.084 mCi ^{90}Sr/km^2. Tables 4.1.2 and 4.1.3 show that the variation between locations was not significant. The mean levels for ten State experimental farms were 0.41 mCi ^{90}Sr/km^2 and 0.82 pCi ^{90}Sr/l. In Appendix A the country mean level (area-weighted) is estimated to be 0.44 mCi ^{90}Sr/km^2 for a mean precipitation amount of 539 mm (area-weighted), i.e. 0.6 times the fall-out in 1974.

A comparison between the amounts of precipitation found in the rain gauges used by the Danish Meteorological Institute[9] and the amounts collected in our rain bottles at the same locations in 1975 showed a mean ratio of 1.15 $\pm$ 0.05 (1 SE) between the two sampling systems. The 1975-summer was warmer than normal. This resulted in a considerable evaporation from our rain bottles as compared to the daily collected rain gauges of the Danish Meteorological Institute, hence the ratio between the two systems became greater than usual.

Table 4.1.1

Strontium-90 fall-out in Denmark in 1975

Period	Unit	Tylstrup	Studsgård	Ødum	Askov	St. Jyndevad	Blangstedgård	Tystofte	Virumgård	Abed	Åkirkeby	Ledreborg	Mean*
Jan.-Feb.	pCi/l	0.80	0.65	0.79	0.80	0.73	0.63	0.76	0.99	0.68	0.92	0.78	0.77
	mCi/km^2	0.087	0.095	0.082	0.113	0.078	0.056	0.066	0.090	0.061	0.061	0.062	0.079
Mar.-Apr.	pCi/l	1.44	1.27	1.35	1.48	1.40	0.87	1.10	1.23	1.05	2.27	1.21	1.35
	mCi/km^2	0.129	0.143	0.109	0.145	0.125	0.074	0.094	0.110	0.101	0.208	0.086	0.124
May-June	pCi/l	2.72	2.95	3.50	5.12	2.65	2.54	6.03	(3.35)	1.55	3.32	3.10	3.18
	mCi/km^2	0.130	0.060	0.064	0.113	0.072	0.048	0.118	(0.075)	0.058	0.108	0.109	0.084
July-Aug.	pCi/l	0.68	1.73	1.10	0.99	1.68	0.77	0.99	(1.07)	0.99	1.01	0.66	1.08
	mCi/km^2	0.056	0.100	0.072	0.084	0.141	0.080	0.056	(0.062)	0.045	0.055	0.040	0.075
Sep.-Oct.	pCi/l	0.27	0.17	0.31	0.16	0.26	0.22	0.38	0.26	0.54	0.29	0.29	0.27
	mCi/km^2	0.026	0.022	0.030	0.024	0.042	0.023	0.022	0.025	0.056	0.033	0.025	0.030
Nov.-Dec.	pCi/l	0.21	0.12	0.36	0.19	0.23	0.32	0.16	0.22	0.13	0.22	0.16	0.20
	mCi/km^2	0.020	0.019	0.027	0.029	0.023	0.030	0.017	0.014	0.015	0.019	0.012	0.020
1975	pCi/l $\bar{x}$	0.86	0.70	0.87	0.78	0.84	0.63	0.90	0.90	0.69	1.09	0.82	0.82
	mCi/km^2 Σ	0.448	0.439	0.384	0.508	0.481	0.311	0.373	0.376	0.336	0.484	0.334	0.414
mm precipitation Σ		520	624	440	649	569	496	[illegible]	420	487	445	407	507

*Ledreborg not included in mean.

Figures in brackets calculated from VAR3[12]

Table 4.1.2

Analysis of variance of ln pCi $^{90}Sr/l$ precipitation in 1975
(from table 4.1.1)

Variation	SSD	f	s^2	v^2	P
Betw. locations	0.789	10	0.079	0.844	-
Betw. months	54.705	5	10.941	117.056	>99.95%
Remainder	4.486	48	0.093		

Table 4.1.3

Analysis of variance of ln mCi $^{90}Sr/km^2$ precipitation in 1975
(from table 4.1.1)

Variation	SSD	f	s^2	v^2	P
Betw. locations	1.297	10	0.130	1.436	-
Betw. months	25.746	5	5.149	57.032	>99.95%
Remainder	4.334	48	0.090		

4.2. Strontium-90 and Caesium-137 in Soil

As in previous years, soil was collected with a view to estimating the accumulated fall-out. The samples were collected in September from uncultivated areas as well as cultivated fields all over the country (cf. fig. 4.1.1) down to a depth of 50 cm. The uncultivated soils were collected at the depths 0-10, 10-20, 20-30 and 30-50 cm while the cultivated soil samples were taken from 0-20, 20-30 and 30-50 cm.

A new sampling technique was used in the 1975 soil programme. The cores were collected by means of two tubes, one inside the other. The outer tube was first pressed down to the full sampling depth of 50 cm, whereafter the inner tube collected the various depth-sections inside the outer tube. This procedure enabled us to avoid contamination of the deeper soil sections by surface soil, because the outer tube lined the bore hole and thus prevented extraneous soil from entering the samples. Eight cores with a diameter of 62 mm were collected at each location.

Tables 4.2.1 and 4.2.2 show the ^{90}Sr results. The mean value of the State experimental farms was 59 mCi $^{90}Sr/km^2$ for uncultivated soil. From precipitation data, the accumulated fall-out in Denmark in 1975 was calculated to be 52 mCi/km^2, (cf. Appendix D). The corresponding determination of ^{137}Cs is shown in tables 4.2.3 and 4.2.4. The mean value of the State experimental farms was 105 mCi $^{137}Cs/km^2$. A closer inspection of

Table 4.2.1

Strontium-90 in uncultivated soil collected at the state experimental farms in 1975 (mCi/km^2)

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyndevad	Blangstedgård	Tystofte	Ledreborg	Abed	Åkirkeby	Mean	SD	SE
0-10	39	41	5.7	22	27	18.4	14.4	16.5	16.6	22	22	10.9	3.4
10-20	12.1	15	6.4	20	27	17.1	14.7	21	21	31	18.5	7.1	2.3
20-30	2.5	5.6	8.5	12.7	23	6.1	9.7	10.6	8.9	5.3	9.3	5.7	1.8
30-50	2.7	4.0	22	12.1	23	3.6	6.5	5.6	2.4 A	3.1	8.5	7.9	2.5
Σ 0-20	51	56	12.1	44	54	36	29	38	37	53	41	14	4
Σ 0-30	54	62	21	54	77	42	39	48	46	58	50	15	5
Σ 0-50	57	66	43	67	100	45	45	54	49	61	59	17	5

Table 4.2.2

Strontium-90 in uncultivated soil collected at the state experimental farms in 1975 (pCi/kg)

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyndevad	Blangstedgård	Tystofte	Ledreborg	Abed	Åkirkeby	Mean	SD	SE
0-10	347	437	40	195	162	176	158	139	305	192	215	115	36
10-20	78	86	41	132	144	141	119	135	249	183	131	58	18
20-30	15	38	49	82	131	37	72	57	76	42	60	32	10
30-50	8.3	15	80	39	49	11.0	20	14.4	6.7 A	15.5	26	23	7
$\bar{x}$ 0-20*	192	209	41	158	152	157	136	137	271	187	164	59	19
$\bar{x}$ 0-30*	123	149	44	136	145	107	112	105	181	142	123	36	11
$\bar{x}$ 0-50*	74	96	57	91	100	63	69	64	79	101	79	16	5

*weighted mean

Table 4.2.3

Caesium-137 in uncultivated soil collected at the state experimental farms in 1975 (mCi/km^2)

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyndevad	Blangstedgård	Tystofte	Ledreborg	Abed	Åkirkeby	Mean	SD	SE
0-10	93	81	30	62	35	41	59	42	30	63	54	22	7
10-20	8.0	8.3	32	31	23	42	16.4	25	36	23	24	11	4
20-30	3.2	3.4	44	18.7	10.1	9.4	7.4	6.8	12.1	5.3	12.0	12.1	3.8
30-50	3.1	2.4 A	118	11.6	1.7 B	0.3 A	5.8	2.8 B	0	1.2 B	14.7	36.5	11.5
Σ 0-20	101	89	62	93	58	83	75	67	66	87	78	15	5
Σ 0-30	104	93	105	112	68	93	83	74	78	92	90	14	5
Σ 0-50	107	95	223	123	70	93	89	77	78	93	105	44	14

Table 4.2.4

Caesium-137 in uncultivated soil collected at the state experimental farms in 1975 (pCi/kg)

Depth in cm	Tylstrup	Studsgård	Ødum	Askov	St. Jyndevad	Blangstedgård	Tystofte	Ledreborg	Abed	Åkirkeby	Mean	SD	SE
0-10	818	860	212	559	213	405	592	346	554	551	511	222	70
10-20	52	47	204	202	122	344	133	159	424	130	182	120	38
20-30	18.7	23	251	121	59	57	55	37	103	42	77	69	22
30-50	9.3	9.1 A	422	37	3.6 B	0.9 A	18.3	7.3 B	0	6.2 B	51	131	41
$\bar{x}$ 0-20*	377	330	208	352	164	371	339	241	475	306	316	91	29
$\bar{x}$ 0-30*	236	222	224	266	130	239	232	159	305	225	224	49	16
$\bar{x}$ 0-50*	139	139	298	169	70	129	131	90	126	154	144	61	19

*weighted mean

the figures in table 4.2.1-4.2.4 reveals that Ødum and St. Jyndevad show unusual vertical distributions of the activity. At Ødum, the 30-50 cm layer shows unexpectedly high concentrations of ^{90}Sr and especially of ^{137}Cs. The concentrations are twice as high as in the upper layers, indicating some extraneous supply of activity. St. Jyndevad shows unusually high ^{90}Sr levels, which may also indicate some extra supply of activity, especially to the deeper layers. Excluding Ødum and St. Jyndevad, the means of the remaining eight stations become 55.5 mCi ^{90}Sr km^{-2} and 94.4 mCi ^{137}Cs km^{-2}. These figures are compatible with the expected values from fall-out (cf. Appendix D) and with the findings in 1974[1].

The mean ratios of $^{137}Cs/^{90}Sr$ of the soil samples (0-50 cm) collected in 1975 were 1.66 for uncultivated soil (Ødum and St. Jyndevad excluded) and 1.63 for cultivated soil (cf. tables 4.2.11 and 4.2.12). These figures are close to the generally accepted ratio of 1.6[21], and we may conclude that the new sampling method prevents the deeper soil sections from being contaminated by surface soil, which has earlier[1] resulted in an overestimate of the $^{137}Cs/^{90}Sr$ ratios in soil samples.

Tables 4.2.6 - 4.2.9 show the ^{90}Sr and ^{137}Cs levels in cultivated soil. Comparing the mean ratios between cultivated and uncultivated soil (0-50 cm), we find 0.89 ± 0.13 (1 SE) for ^{90}Sr and 0.75 ± 0.08 for ^{137}Cs. A corresponding study was made in 1973 but only to a depth of 30 cm. The corresponding ratios at that time were 0.95 ± 0.07 and 1.02 ± 0.05, respectively. We may conclude from the two samplings that cultivated soil from the State experimental farms contains approx. 10 percent less activity than uncultivated.

Table 4.2.5

g K/kg uncultivated soil collected at the state experimental farms in 1975

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyn-devad	Blang-stedgård	Tystofte	Ledre-borg	Abed	Åkir-keby	Mean	SD	SE
0-10	13.9	5.8	12.7	10.6	7.8	14.7	16.4	18.6	15.1	18.3	13.4	4.2	1.3
10-20	14.0	5.9+0.0	13.0	9.4	7.8	15.2	16.1	17.8	12.1	18.5	13.J	4.2	1.3
20-30	13.6	7.5+0.0	13.2	10.7	7.4	13.3	17.0	19.0	15.3	13.4	13.0	3.7	1.2
30-50	13.9	9.1	13.4	11.3	8.3	13.0	15.3	19.6	14.1	19.6	13.8	3.8	.2
$\bar{x}$ 0-20*	14.0	5.8	12.9	9.9	7.8	15.0	16.2	18.1	13.3	18.5	13.2	4.2	1.3
$\bar{x}$ 0-30*	13.8	6.4	13.0	10.2	7.7	14.3	16.5	18.5	14.2	16.9	13.2	3.9	1.2
$\bar{x}$ 0-50*	13.8	7.5	13.1	10.7	8.0	13.7	15.9	19.0	14.2	17.8	13.4	3.8	1.2

*weighted mean

Table 4.2.6

Strontium-90 in cultivated soil collected at the state experimental farms in 1975 (nCi/km^2)

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyn-devad	Blang-stedgård	Tystofte	Ledre-borg	Abed	Åkir-keby	Mean	SD	SE
0-20	42	17.5	27	32	32	14.2	31	24	19.8	25	26	8	3
20-30	20	9.9	11.4	9.2	2.6	7.5	10.4	5.7	11.4	11.1	9.9	4.5	1.4
30-50	13.2	9.7	8.3	8.2	3.3	24	15.2	3.0	4.0	7.5	9.6	6.4	2.0
Σ 0-30	63	27	38	41	34	22	41	30	31	36	36	11	4
Σ 0-50	76	37	47	49	37	45	57	33	35	44	46	13	4

Table 4.2.7

Strontium-90 in cultivated soil collected at the state experimental farms in 1975 (pCi/kg)

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyn-devad	Blang-stedgård	Tystofte	Ledre-borg	Abed	Åkir-keby	Mean	SD	SE
0-20	165	57	102	129	86	83	123	89	83	106	102	30	10
20-30	127	49	83	74	16.1	68	83	41	63	78	63	29	9
30-50	36	28	26	31	9.7	99	50	8.3	14	22	32	27	8
$\bar{x}$ 0-30*	[illegible]	54	95	111	65	77	110	73	74	93	90	28	9
$\bar{x}$ 0-50*	96	43	65	78	43	87	83	43	50	60	65	20	6

*weighted mean

Table 4.2.8

Caesium-137 in cultivated soil collected at the state experimental farms in 1975 (nCi/km^2)

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyn-devad	Blang-stedgård	Tystofte	Ledre-borg	Abed	Åkir-keby	Mean	SD	SE
0-20	73	84	63	69	76	34	60	45	36	52	59	17	5
20-30	26	11.8	13.8	11.2	4.3	12.3	15.7	1.8 A	9.9	12	11.9	6.5	2.1
30-50	3.0 B	4.2 A	3.5 A	3.5 A	0.5 B	2.5 A	3.3	0.6 B	0	0	2.1	1.6	0.5
Σ 0-30	99	96	77	80	80	46	76	46	46	64	71	20	6
Σ 0-50	102	100	80	84	81	48	80	47	46	64	73	21	7

Table 4.2.9

Caesium-137 in cultivated soil collected at the state experimental farms in 19[illegible] (pCi/kg)

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyn-devad	Blang-stedgård	Tystofte	Ledre-borg	Abed	Åkir-keby	Mean	SD	SE
0-20	285	276	238	279	207	196	241	167	149	218	226	47	15
20-30	162	59	97	91	27	113	125	13.1 A	55	88	83	45	14
30-50	8.0 B	12.0A	10.9A	13.2A	1.4 B	10.5 A	11.1	1.6 B	0	0	6.9	5.4	1.7
$\bar{x}$ 0-30*	237	190	188	216	153	164	202	115	109	169	174	41	13
$\bar{x}$ 0-50*	129	117	110	132	94	93	117	62	65	89	101	25	8

*weighted mean

Table 4.2.10

g K/kg cultivated soil collected at the state experimental farms in 1975

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyn-devad	Blang-stedgård	Tystofte	Ledre-borg	Abed	Åkir-keby	Mean	SD	SE
0-20	13.4	6.8	17.6	12.0	9.6	16.6	15.6	18.5	15.6	21.7	14.7	4.4	1.4
20-30	13.4	7.7	18.6	11.5	18.0	16.3	16.7	19.4	17.0	21.9	16.0	4.1	1.3
30-50	7.2	8.6	16.7	12.1	10.6	16.6	17.1	19.9	16.2	20.4	14.5	4.6	1.5
$\bar{x}$ 0-30*	13.4	7.1	18.0	11.8	12.1	16.5	16.0	18.8	16.2	21.8	15.2	4.2	1.3
$\bar{x}$ 0-50*	10.5	7.8	17.4	11.9	11.5	16.6	16.5	19.3	16.2	21.1	14.9	4.2	1.3

*weighted mean

Table 4.2.11

The ratio $^{137}Cs/^{90}Sr$ in uncultivated soil from the state experimental farms, 1975 (from tables 4.2.1 and 4.2.3)

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyn-devad	Blang-stedgård	Tystofte	Ledre-borg	Abed	Åkir-keby	Mean	SD	SE
0-10	2.38	1.97	5.26	2.81	1.29	2.22	4.10	2.54	1.80	2.86	2.72	1.17	0.37
10-20	0.66	0.55	5.00	1.55	0.85	2.45	1.11	1.19	1.71	0.74	1.58	1.33	0.42
20-30	1.28	0.60	5.17	1.47	0.43	1.54	0.76	0.64	1.35	1.00	1.42	1.37	0.43
30-50	1.14	0.60	5.36	0.95	0.07	0.08	0.89	0.50	0	0.38	1.00	1.58	0.50
$\bar{x}$ 0-20	1.98	1.59	5.12	2.11	1.07	2.31	2.59	1.76	1.78	1.64	2.20	1.11	0.35
$\bar{x}$ 0-30	1.93	1.50	5.00	2.07	0.88	2.21	2.13	1.54	1.70	1.59	2.06	1.11	0.35
$\bar{x}$ 0-50	1.88	1.44	5.19	1.84	0.70	2.07	1.98	1.43	1.59	1.52	1.96	1.20	0.38

Table 4.2.12

The ratio $^{137}Cs/^{90}Sr$ in cultivated soil from the state experimental farms, 1975 (from tables 4.2.6 and 4.2.8)

Depth in cm	Tylstrup	Studs-gård	Ødum	Askov	St. Jyn-devad	Blang-stedgård	Tystofte	Ledre-borg	Abed	Åkir-keby	Mean	SD	SE
0-20	1.73	4.80	2.33	2.15	2.37	2.39	1.93	1.87	1.81	2.08	2.35	0.89	0.28
20-30	1.30	1.19	1.21	1.21	1.65	1.64	1.50	0.31	0.86	1.08	1.20	0.40	0.13
30-50	0.22	0.43	0.42	0.42	0.15	0.10	0.21	0.20	0	0	0.22	0.16	0.05
$\bar{x}$ 0-30	1.57	3.56	2.03	1.95	2.35	2.09	1.85	1.53	1.48	1.78	2.02	0.61	0.19
$\bar{x}$ 0-50	1.34	2.70	1.70	1.71	2.19	1.07	1.40	1.42	1.31	1.45	1.63	0.48	0.15

A comparison of the vertical activity distributions below 20 cm in 1975 shows great local variations. At Tylstrup, Studsgård, Blangstedgård and Åkirkeby the ^{90}Sr as well as the ^{137}Cs levels indicate greater penetration into the deeper layers of cultivated soil than into uncultivated. At Ledreborg and Askov the opposite is the case. On average the cultivated soils below 20 cm contain more activity than the uncultivated. This was also the case in 1973 when 3 of the 10 stations (Ødum, Jyndevad and Abbed) were examined down to a depth of 50 cm. The observations suggest that the cultivation of the soil may enhance the vertical migration of the activity. Squire[22] has experimentally shown that the application of fertilizers increases the penetration of radiostrontium, but not of radiocaesium. In agreement with these experimental results, it appears (cf. table 4.2.11 - 4.2.12) that the verical movement of ^{90}Sr in cultivated soil is relatively greater than that of ^{137}Cs compared to uncultivated soil. The $^{137}Cs/^{90}Sr$ ratios in the 30-50 cm layer are thus significantly higher in uncultivated soil than in cultivated.

The vertical distribution of the activity may be described by exponential expressions[26] if we disregard the upper layers, e.g. 0-20 cm, corresponding to the thickness of the ploughing layer. The following expressions were found:

^{90}Sr in cultivated soil:	$y = 1.17\, e^{-0.054x}$	eqv.(4.2.1)
^{90}Sr in uncultivated soil:	$y = 1.10\, e^{-0.065x}$	eqv.(4.2.2)
^{137}Cs in cultivated soil:	$y = 1.87\, e^{-0.17x}$	eqv. (4.2.3)
^{137}Cs in uncultivated soil (Ødum excluded):	$y = 1.53\, e^{-0.15x}$	eqv. (4.2.4)

where y is the activity of a 1 cm thick layer in mCi km^{-2} of the respective nuclide at the depth (x + 20) cm. We may now estimate the total integrated deposit of ^{90}Sr and ^{137}Cs in the two soil types (cf. table 4.2.19). The activities of the 0-20 cm layer are taken from tables 4.2.6, 4.2.1, 4.2.8 and 4.2.3, respectively, and the activities below 20 cm are calculated as the infinite integrals from the above four equations. It appears that a sampling depth of 50 cm seems adequate in all cases, except for ^{90}Sr in cultivated soil where on average 2 mCi ^{90}Sr km^{-2} may have penetrated below 50 cm.

The crops accumulate radionuclides both by direct and indirect contamination. The direct contamination prevents some debris from reaching the soil and the indirect contamination removes some activity already present in the soil. Table 4.2.20 shows that 1-2% of the ^{90}Sr and ^{137}Cs deposited over average arable land during 1950-1975 have been removed net by crops; but this is not sufficient to account for the 10% deficiency of activity in cultivated soils found in this study. However, in most cases the State experimental farms do not use manure[23], and the crops here have thus removed 6-7% of the ^{90}Sr and ^{137}Cs deposition.

Table 4.2.13

Strontium-90 in uncultivated and cultivated soil from the surroundings of Risø, 1975 (mCi/km^2)

Depth in cm	Bolund uncultivated	Skydebanen uncultivated	Mean uncultivated	SD	SE	Risø cultivated
0-10	25	29	27	3	2	
0-20						2.9
10-20	10.7	12.7	11.7	1.4	1.0	
20-30	6.0	4.5	5.2	1.1	0.8	5.9
30-50	1.3	1.6 A	1.7	0.1	0.1	2.2
Σ 0-20	36	42	39	4	3	2.9
Σ 0-30	42	46	44	3	2	8.8
Σ 0-50	44	48	46	3	2	11.0

Table 4.2.14

Strontium-90 in uncultivated and cultivated soil from the surroundings of Risø, 1975 (pCi/kg)

Depth in cm	Bolund uncultivated	Skydebanen uncultivated	Mean uncultivated	SD	SE	Risø cultivated
0-10	275	320	298	32	22	
0-20						17.5
10-20	93	109	101	11	8	
20-30	31	31	31	0	0	51
30-50	6.9	6.2 A	6.6	0.5	0.4	11.7
$\bar{x}$ 0-20*	174	2[illegible]1	188	19	14	17.5
$\bar{x}$ 0-30*	105	131	118	18	13	31
$\bar{x}$ 0-50*	67	78	72	8	6	23

*weighted mean

Table 4.2.15

Caesium-137 in uncultivated and cultivated soil
from the surroundings of Risø, 1975 (mCi/km^2)

Depth in cm	Bolund uncultivated	Skydebanen uncultivated	Mean uncultivated	SD	SE	Risø cultivated
0-10	42	57	50	11	8	
0-20						28
10-20	16.1	13.9	15.0	1.6	1.1	
20-30	9.0	1.9 A	5.4	5.0	3.6	5.3
30-50	0.1 B	2.6 A	1.4	1.8	1.2	3.2 B
Σ 0-20	58	71	64	9	6	28
Σ 0-30	57	73	65	11	8	33
Σ 0-50	57	75	66	13	9	37

Table 4.2.16

Caesium-137 in uncultivated and cultivated soil
from the surroundings of Risø, 1975 (pCi/kg)

Depth in cm	Bolund uncultivated	Skydebanen uncultivated	Mean uncultivated	SD	SE	Risø cultivated
0-10	460	635	548	124	88	
0-20						172
10-20	140	118	129	16	11	
20-30	47	13.2 A	30	24	17	45
30-50	0.3 B	10.4 A	5.4	7.1	5.0	17.1 B
$\bar{x}$ 0-20*	282	342	312	42	30	172
$\bar{x}$ 0-30*	169	207	188	27	19	119
$\bar{x}$ 0-50*	103	124	114	15	10	78

*weighted mean

Table 4.2.17

g K/kg uncultivated and cultivated soil
from the surroundings of Risø, 1975

Depth in cm	Bolund uncultivated	Skydebanen uncultivated	Mean uncultivated	SD	SE	Risø cultivated
0-10	14.9	16.7	15.8	1.3	0.9	
0-20						17.8
10-20	16.8	17.0	16.9	0.1	0.1	
20-30	9.7	15.7	12.7	4.2	3.0	19.9
30-50	12.0	14.8	16.4	2.3	1.6	18.4
$\bar{x}$ 0-20*	16.0	16.8	16.4	0.6	0.4	17.8
$\bar{x}$ 0-30*	13.0	16.4	14.7	2.4	1.7	18.7
$\bar{x}$ 0-50*	14.9	15.7	15.3	0.6	0.4	18.6

*weighted mean

Table 4.2.18

The ratio $^{137}Cs/^{90}Sr$ in uncultivated and cultivated
soil from the surroundings of Risø, 1975
(from tables 4.2.13 and 4.2.15)

Depth in cm	Bolund uncultivated	Skydebanen uncultivated	Mean uncultivated	SD	SE	Risø cultivated
0-10	1.68	1.97	1.83	0.21	0.15	
0-20						9.66
10-20	1.50	1.09	1.30	0.29	0.21	
20-30	1.50	0.42	0.96	0.76	0.54	0.90
30-50	0.06	1.63	0.85	1.11	0.78	1.45
$\bar{x}$ 0-20	1.61	1.69	1.65	0.06	0.04	9.66
$\bar{x}$ 0-30	1.36	1.59	1.48	0.16	0.11	3.75
$\bar{x}$ 0-50	1.30	1.56	1.43	0.18	0.13	3.36

Table 4.2.19

An estimate of the ^{90}Sr and ^{137}Cs deposit in soil below the sampling depth of 50 cm

Sample	Nuclide	Total integrated level in soil (0-20 cm measured and 20-∞ cm calculated cf. text)	Measured level 0-50 cm $mCi\ km^{-2}$	Ratio between 0-50 cm level and estimated total deposit
Cultivated soil (cf. table 4.2.6)	^{90}Sr	26.4+21.6 = 48	46	0.96
Uncultivated soil (cf. table 4.2.1)	^{90}Sr	41 + 17 = 58	58.7	1.01
Cultivated soil (cf. table 4.2.8)	^{137}Cs	11 + 59 = 70	73	1.04
Uncultivated soil (except Ødum) (cf. table 4.2.3)	^{137}Cs	10 + 80 = 90	91	1.01

Table 4.2.20

An estimate of the total ^{90}Sr and ^{137}Cs uptake by Danish crops 1950-75

	20,24) Mean area 1950-75 km^2	20,24) Mean production $kg\ y^{-1}$	^{90}Sr 1)		^{137}Cs 1)	
			$pCi\ kg^{-1}\ y$	Ci	$pCi\ kg^{-1}\ y$	Ci
Grain	14,000	$5 \cdot 10^9$	$1.5 \cdot 10^3$	8	$3.8 \cdot 10^3$	19
Straw		$2 \cdot 10^9$	$10 \cdot 10^3$	20	$\sim 19 \cdot 10^3$	38
Roots	5,000	$20 \cdot 10^9$	$0.4 \cdot 10^3$	8	$\sim 4 \cdot 10^3$	80
Leaves		$5 \cdot 10^9$	$2 \cdot 10^3$	10	$\sim 1 \cdot 10^3$	5
Grass	6,000	$20 \cdot 10^9$	$3.6 \cdot 10^3$	72	$\sim 4 \cdot 10^3$	80
Permanent grass	4,000	$13 \cdot 10^9$	$3.6 \cdot 10^3$	(47)	$\sim 4 \cdot 10^3$	(52)
Other crops	1,000	$0.03 \cdot 10^9$	$\sim 2 \cdot 10^3$	∿ 0	$\sim 1 \cdot 10^3$	∿ 0
Σ	30,000			118		222

Total fallout on 30,000-4,000 = 26,000 km^{-2} 26·73 Ci = 1898 Ci ^{90}Sr and 26·73·1.6 = 3037 Ci ^{137}Cs (not decay corrected) crops has carried 6.2% of the ^{90}Sr and 7.3% of the ^{137}Cs deposit. However, 80% returns to the fields as manure[23] hence 1.2% and 1.5% of the ^{90}Sr and ^{137}Cs respectively have been removed permanently by the crops.

It is remarkable that the cultivated soil from Abed in particular shows relatively low activity levels. Abed is located in zone VII (Lolland-Falster), where beet for sugar production are an important crop (409 km^2 with a beet production of 1.7×10^6 tons in 1974[24]). The beet carry approx. 29% of their own weight of adhering soil, which is descarded into the sea[25]. As a result approx. 5×10^5 tons of soil are removed every year from the beet fields of Lolland-Falster, or 1.2 kg m^{-2}, which corresponds to approx.

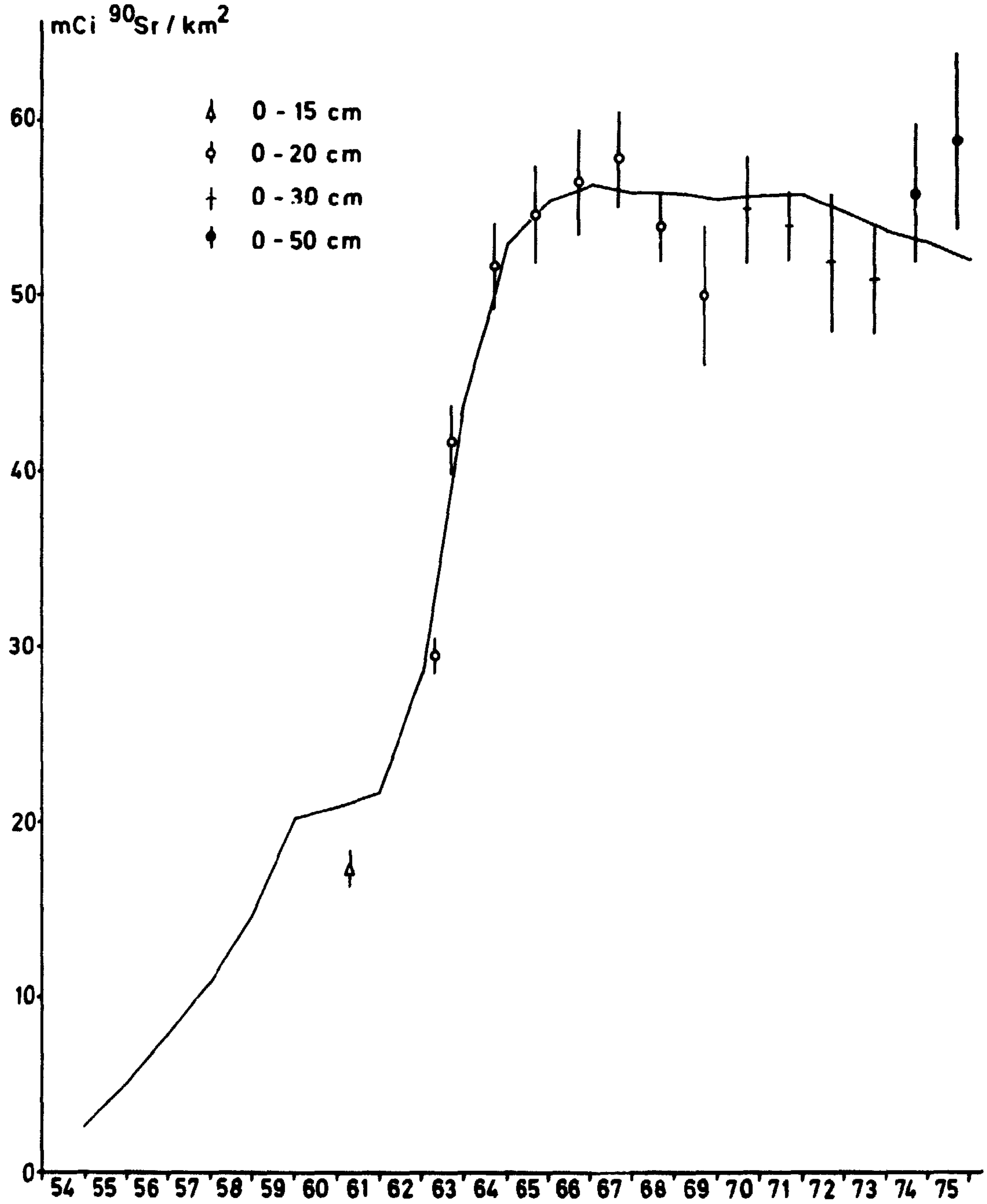

Fig. 4.2. A comparison between measured levels in soil collected in various depths ($\pm$ 1 S. E.) and calculated (the curve) assuming an effective half-life of 27.7 y.

1 mm or 0.5% p.a. of the ploughing layer. Although this removal of soil reduces the activity content of the cultivated soil, it is not sufficient to fully account for the low levels found at Abed. If we consider other parts of the country where sugar beet is less dominant, this removal of the activity may be without significance. However, some soil is also carried away from arable land by agricultural machinery (e.g. tractor wheels) and by soil drift.

This soil drift may play a role because the fine particles are especially susceptible to long-distance drifting. The fine particles, e.g. clay minerals, may be enriched in fall-out nuclides due to a higher ion exchange capacity than that of coarse particles, e.g. quartzgrains. It is, however, extremely difficult to quantify the importance of soil drifting because of the lack of basic data.

We may conclude that several factors are responsible for the lower activity levels observed in cultivated soil than in corresponding uncultivated. Local conditions, such as agricultural practice, soil characteristics, and climate, are all factors of importance in this context. In the case of ^{90}Sr some of the "missing" activity of the cultivated soils may be due to the penetration of ^{90}Sr below the sampling depth of 50 cm. In the present material the removal of activity with the crops seems to be of importance. Therefore, for the average cultivated soil in Denmark, we may expect levels higher than those found in this study.

4.3. Strontium-90 in Ground Water

As in previous years, ground water was collected in March from the nine locations selected by the Geological Survey of Denmark.

Figure 4.3.1 shows the sample locations and table 4.3.1 the results of the ^{90}Sr analyses (cf. also 5.8.4).

The median level of ^{90}Sr in 1975 was 3 times higher than that found in 1974. Figure 4.3.2 shows the median levels in Danish ground water since 1961.

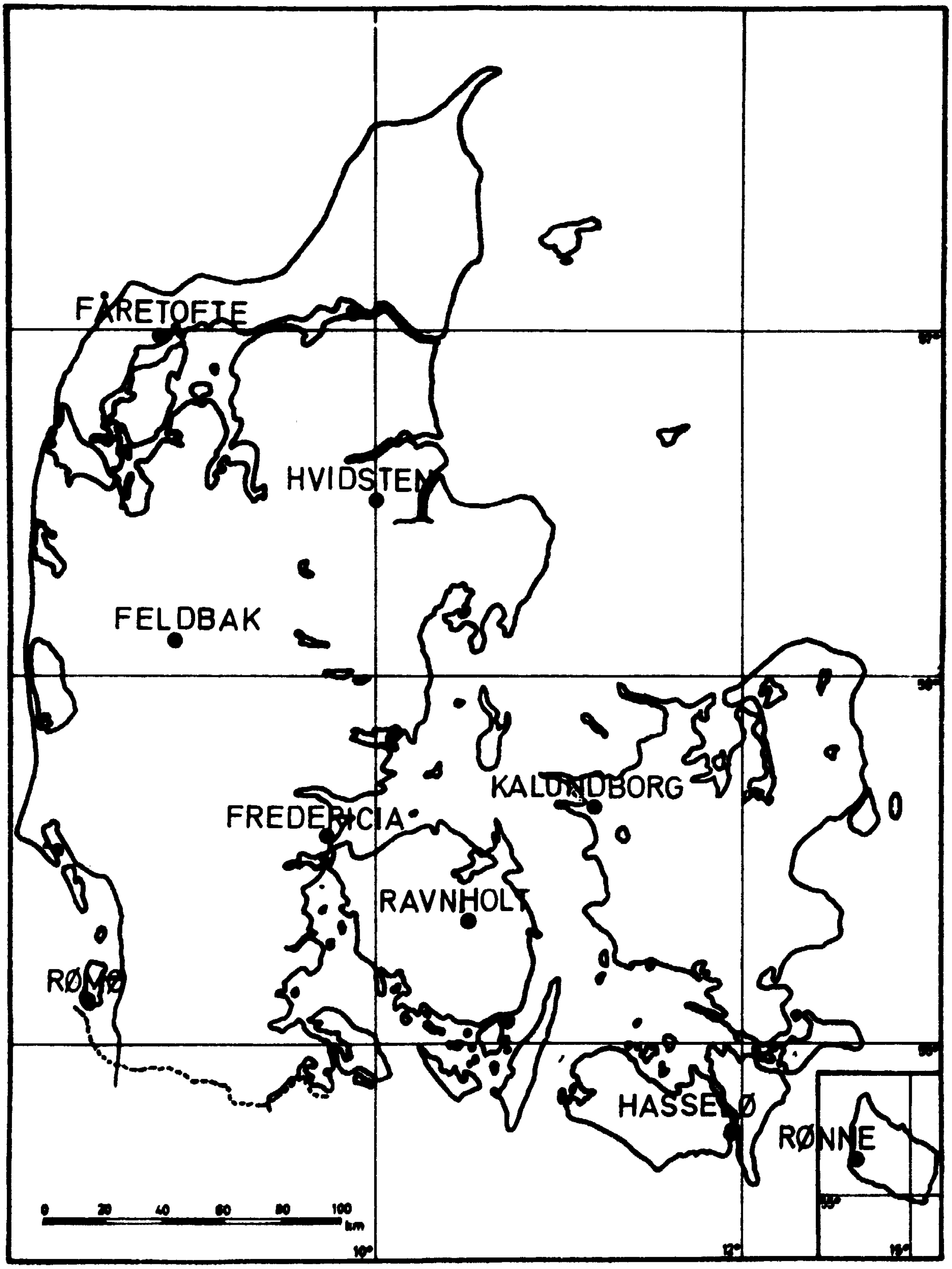

Fig. 4.3.1. Ground-water sampling locations in Denmark.

Table 4.3.1

Strontium-90 in ground water collected in March 1975

	^{90}Sr pCi/l	g Ca/l
Hvidsten	0.006 A	0.0343
Feldbak	1.44	0.0251
Rømø	0.021 A	0.0415
Rønne	0.074	0.0625
Hasselø	0.007	0.1095
Fåretofte	0.002 B	0.0927
Kalundborg	0.031	0.1000
Ravnholt	0.004 B	0.0405
Fredericia	0.017 A	0.0528
Mean	0.178	0.0621
Median	0.017	0.0528

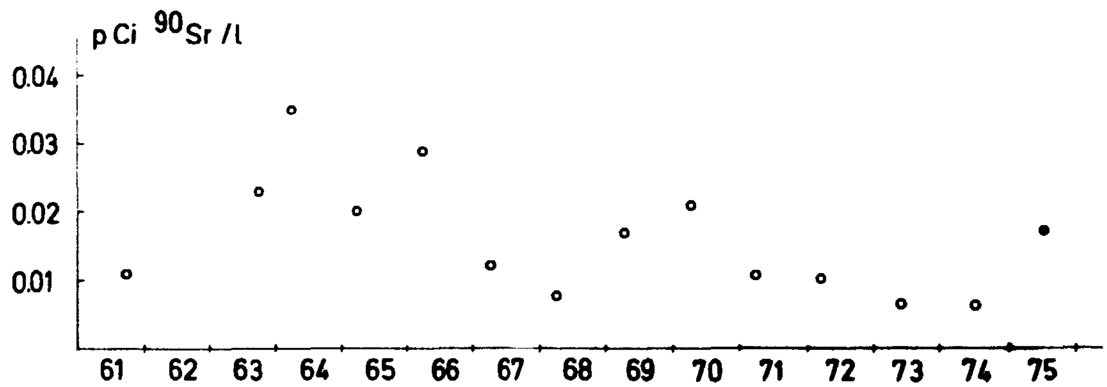

Fig. 4.3.2. Median ^{90}Sr levels in Danish ground water, 1961-75.

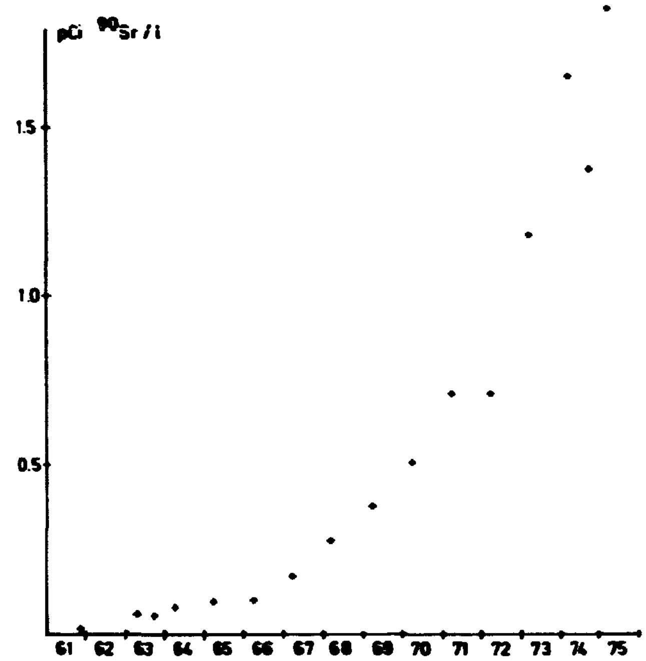

Fig. 4.3.3. Strontium-90 in ground water at Feldbak, 1961-75.

4.4. Strontium-90 in Fresh Water from Danish Streams and Lakes

In March and September we repeated the sampling of fresh water from Danish streams and lakes, first carried out in 1971 (Risø Report No. 265[1]), in 1973 only in March (Risø Report No. 305[1]).

Comparing the mean levels for the three years, we notice that the 1973 levels were a little lower than 1971. In 1975 the level were a little heigher than 1973.

The streams contained 0.37 pCi ^{90}Sr/l in 1971, 0.31 pCi/l in 1973 and 0.33 pCi/l in 1975. The mean levels in the lakes were 1.50 pCi ^{90}Sr/l, 1.29 pCi/l and 1.34 pCi/l respectively. However, an anova showed that the difference between the levels from the three years was not significant.

Table 4.4.2 shows that the ^{90}Sr levels in a neighbouring lake and stream to Feldbak, where the relatively high ^{90}Sr levels are found in the groundwater (cf. fig. 4.3.3), are not unusual for Danish lake and stream water.

Table 4.4.1

Strontium-90 in Danish streams and lakes. March and September 1975

Location		March		September		Symbol on map (fig. 4.4 in Risø Report No. 265)
Stream or lake	Country part	pCi ^{90}Sr/l	g Ca/l	pCi ^{90}Sr/l	g Ca/l	
Bangsbo å (stream)	N-Jutland	0.45	0.055	0.32	lost	1 å
Nors sø (lake)	N-Jutland	2.52	0.049	1.88	0.034	1 s
Gudenå (stream)	E-Jutland	0.43	0.052	0.25	0.050	2 å
Mossø (lake)	E-Jutland	0.48	0.066	0.34	0.074	2 s
Skjern å (stream)	W-Jutland	0.30	0.032	0.36	0.030	3 å
Flyndersø (lake)	W-Jutland	0.52 B	0.038	0.[illegible]6	0.050	3 s
Ribe å (stream)	S-Jutland	0.23	0.039	0.12	0.070	4 å
Hostrup sø (lake)	S-Jutland	2.02	0.032	2.19	0.043	4 s
Odense å (stream)	Funen	0.28	0.113	0.14	0.104	5 å
Arreskov sø (lake)	Funen	0.94	0.078	1.17	0.075	5 s
Suså (stream)	Zealand	0.42	0.116	0.38	0.086	6 å
Arresø (lake)	Zealand	1.02	0.089	1.0[illegible]	0.078	6 s
Halsted å (stream)	Lolland-Falster	0.36	0.178	0.35	0.130	7 å
Søndersø (lake)	Lolland-Falster	1.60	0.094	2.10	0.087	7 s
*Læs å (stream)	Bornholm	0.68	0.070			8 å
*Alm. Gråmyresø (lake)	Bornholm	1.24	0.040			8 s
Stream mean ±1 S.E.		0.39±0.05	0.082±0.018	0.27±0.04	0.078±0.015	
Lake mean ±1 S.E.		1.29±0.25	0.061±0.009	1.29±0.30	0.063±0.008	

Figures in brackets calculated from VAR3[12)]

*Collected in June.

Table 4.4.2

Strontium-90 in water from Feldbak (stream and lake) in 1975

	March		September	
	pCi ^{90}Sr/l	g Ca/l	pCi ^{90}Sr/l	g Ca/l
Stream	0.43	0.055	0.36 A	0.032
Lake	0.72	0.115	0.65	0.078

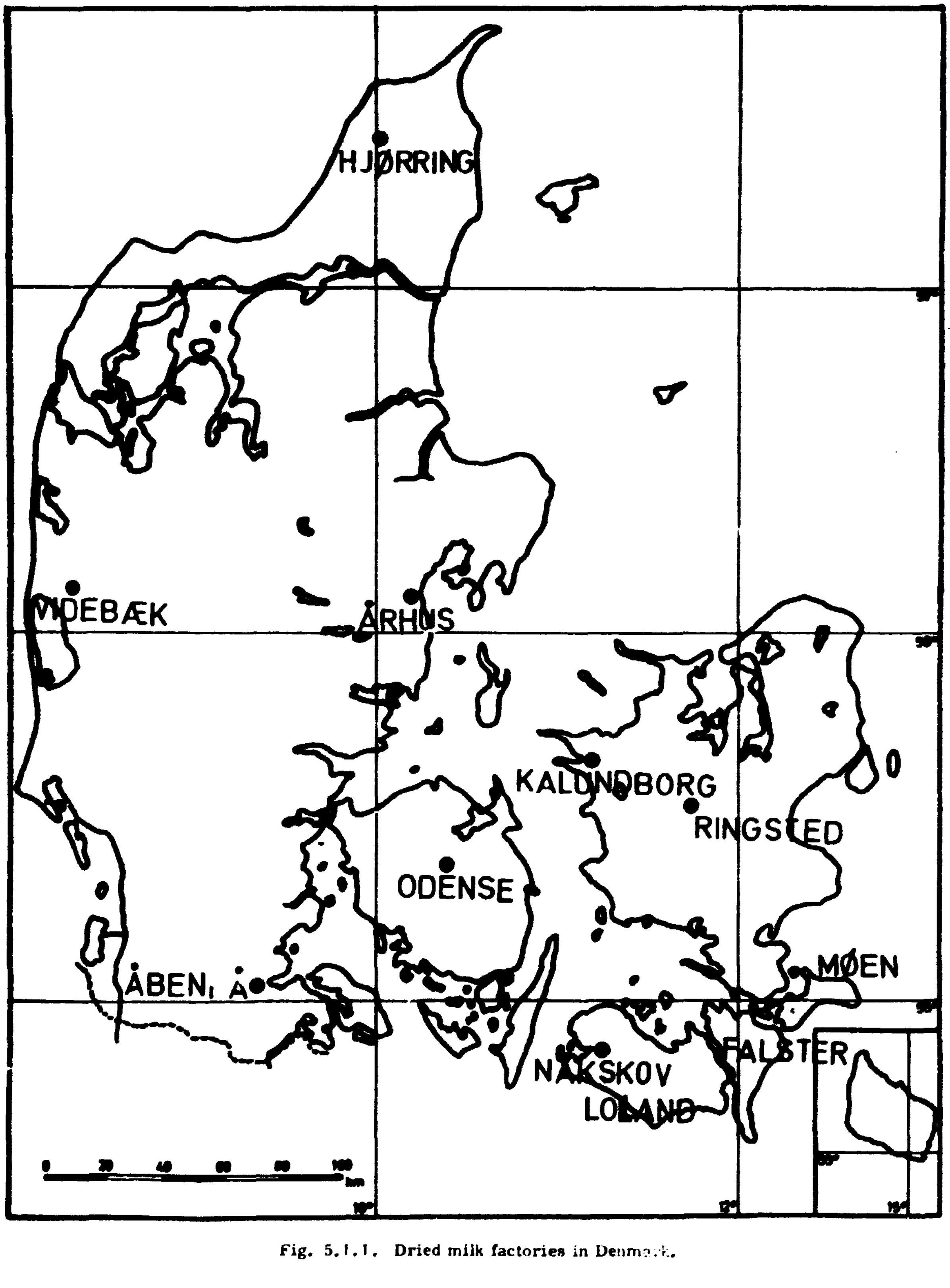

Fig. 5.1.1. Dried milk factories in Denmark.

5. RADIOSTRONTIUM AND RADIOCAESIUM IN DANISH FOOD IN 1975

5.1. Strontium-90 and Caesium-137 in Dried Milk from the Entire Country

As in the previous years, monthly samples of dried milk were collected from seven locations in Denmark (cf. fig. 5.1.1) and analysed for ^{90}Sr and ^{137}Cs.

Table 5.1.1 shows the results of the ^{90}Sr determinations and table 5.1.2 the analysis of variance of the results. As in 1972, 1973 and 1974, the variation between months was significant for S. U., the levels in the first months of the year were the highest. The S. U. mean level in 1975 was 4.1 pCi ^{90}Sr/g Ca, i. e. a little lower than the 1974 mean.

As previously, milk from eatern Denmark showed significantly lower levels than that from Jutland.

Table 5.1.3 shows the results of the ^{137}Cs determinations and table 5.1.4 the analysis of variance of the results. The M. U. mean level in 1975 was 3.7 pCi ^{137}Cs/g K or 16% lower than the 1974 level.

Figures 5.1.2 - 5.1.5 show the S. U. and M. U. levels in dried milk compared with the predicted values (cf. Appendix C).

Table 5.1.1

Strontium-90 (pCi/g Ca) in Danish dried milk in 1975

Month	Hjørring	Århus	Videbæk	Åbenrå	Odense	Ringsted	Lolland-Falster Møn	Mean
Jan.	4.6	5.8	7.2	7.9	3.2	3.8	2.8	5.0
Feb.	5.5	6.6	7.0	7.3	3.5	4.5	3.0	5.3
Mar.	4.2	5.1	7.2	6.5	3.7	3.9	3.3	4.8
Apr.	4.0	4.4	6.1	4.7	3.6	3.1	2.6	4.1
May	4.8	4.6	6.1	5.3	4.3	3.7	4.5	4.8
June	5.3	4.4	5.1	5.5±0.0	3.6	2.7	2.0	4.1
July	3.5	3.1	5.2	4.5	3.2 A	1.8 A	2.1	3.3
Aug.	3.1 A	3.8	4.7	3.3	2.5	2.3 A	2.4	3.2
Sep.	3.8	3.5	4.8±0.1	4.6	3.0	2.4	2.5	3.5
Oct.	4.7	3.5	5.0	4.8	3.1	3.8	2.0	3.8
Nov.	4.1	3.5	5.0	4.7	3.5	2.4	2.0	3.6
Dec.	4.3	3.7	5.4	4.9	3.5	2.6	2.2	3.8
Mean	4.3	4.3	5.7	5.3	3.4	3.1	2.6	4.1

As 1 litre of milk contains 1.2 g Ca, the mean ^{90}Sr content in Danish milk produced in 1975 was 4.9 pCi/l.

Table 5.1.2

Analysis of variance of ln pCi ^{90}Sr/g Ca in dried milk in 1975
(from table 5.1.1)

Variation	SSD	f	s^2	v^2	P
Betw. locations	6.400	6	1.067	58.207	>99.95%
Betw. months	2.281	11	0.207	11.317	>99.95%
Remainder	1.209	66	0.018		

Table 5.1.3.

Caesium-137 (pCi/g K) in Danish dried milk in 1975

Month	Hjørring	Århus	Videbæk	Åbenrå	Odense	Ringsted	Lolland-Falster Møn	Mean
Jan.	3.1	5.0	4.2	5.0	3.0	1.5	1.7 A	3.4
Feb.	3.8	2.7	5.2	4.8	3.6	4.2	4.9	4.2
Mar.	5.2	3.7	7.3	(5.7)	2.3 A	3.0	2.2	4.2
Apr.	5.5	4.3	2.9 A	3.3±0.4	3.2	0.6 B	3.4	3.3
May	4.5	1.0 B	5.0	4.1	2.5	1.9	0.9 B	2.8
June	5.6	6.6	9.1	5.3	2.4	0.9	1.7 A	4.5
July	8.5	5.2	9.3	5.4	3.1	2.5	2.4	5.2
Aug.	7.9	5.9	8.6	7.7	1.8 A	3.4	1.1 B	5.2
Sep.	2.9 A	2.9	6.2±0.8	4.8	0.7 B	1.6 A	0.5 B	2.8
Oct.	4.3	2.2	4.6	3.7	0.6 A	1.5 A	0.8 B	2.5
Nov.	2.0 A	3.7	4.3	4.0	2.6 A	0.8 B	2.0	2.8
Dec.	3.6	4.4	3.9	3.4	3.2	4.0 A	1.2 A	3.4
Mean	4.7	4.0	5.9	4.8	2.4	2.2	1.9	3.7

As 1 litre of milk contains 1.66 g K, the mean ^{137}Cs content in Danish milk in 1975 was estimated at 6.1 pCi/l.

Table 5.1.4

Analysis of variance of ln ^{137}Cs pCi/g K in Danish dried milk 1975
(from table 5.1.3)

Variation	SSD	f	s^2	v^2	P
Betw. locations	5.911	11	0.537	2.505	>97.5%
Betw. months	18.688	6	3.115	14.520	>99.95%
Remainder	13.943	65	0.215		

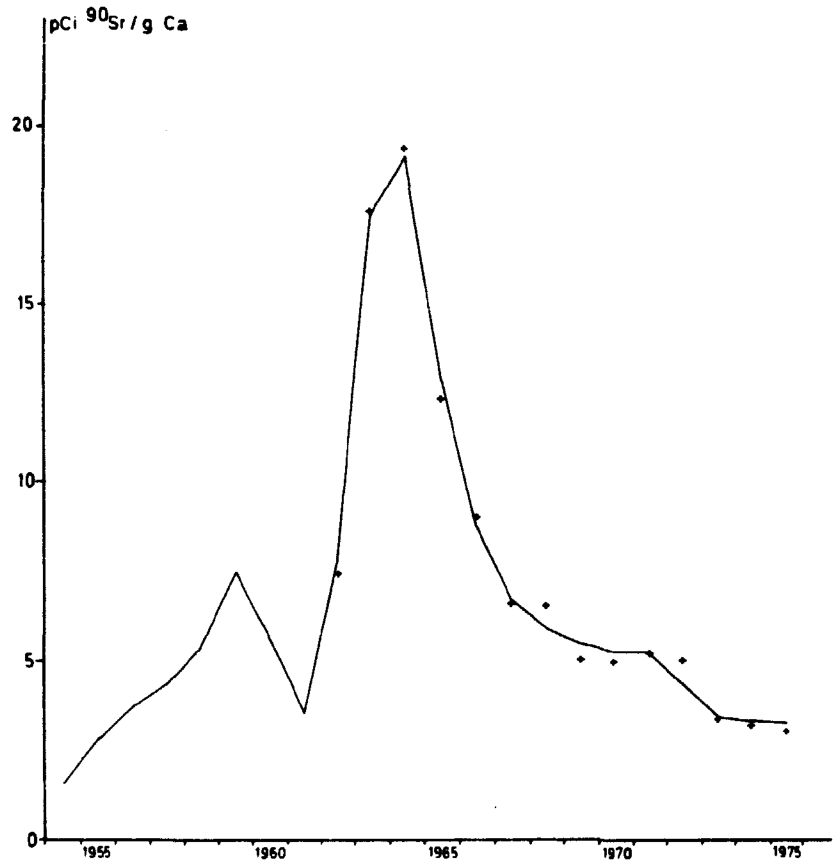

Fig. 5.1.2. A comparison between observed and calculated (curve, cf. appendix C) S. U. -levels in dried milk from the Islands.

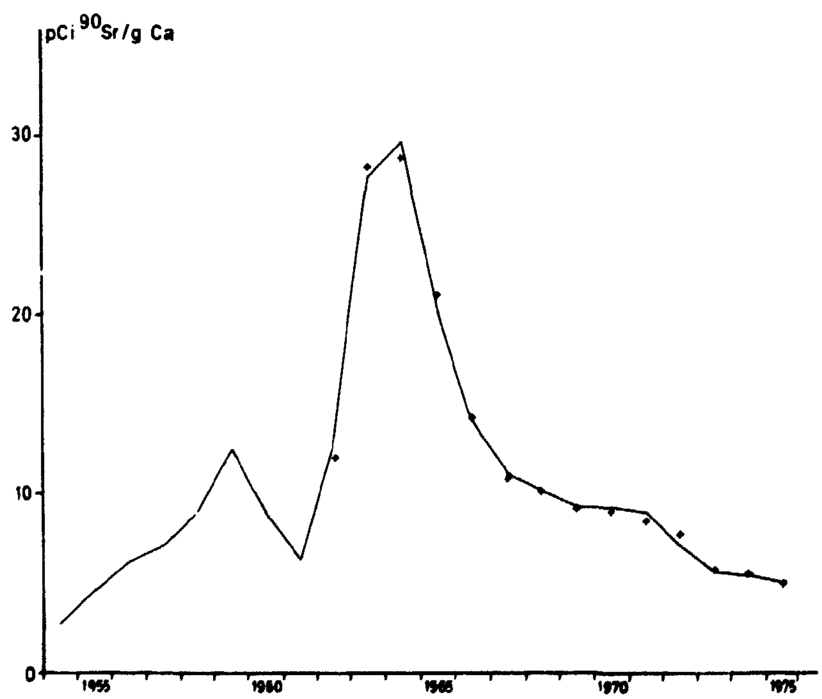

Fig. 5.1.3. A comparison between observed and calculated (curve, cf. appendix C) S. U. -levels in dried milk from Jutland.

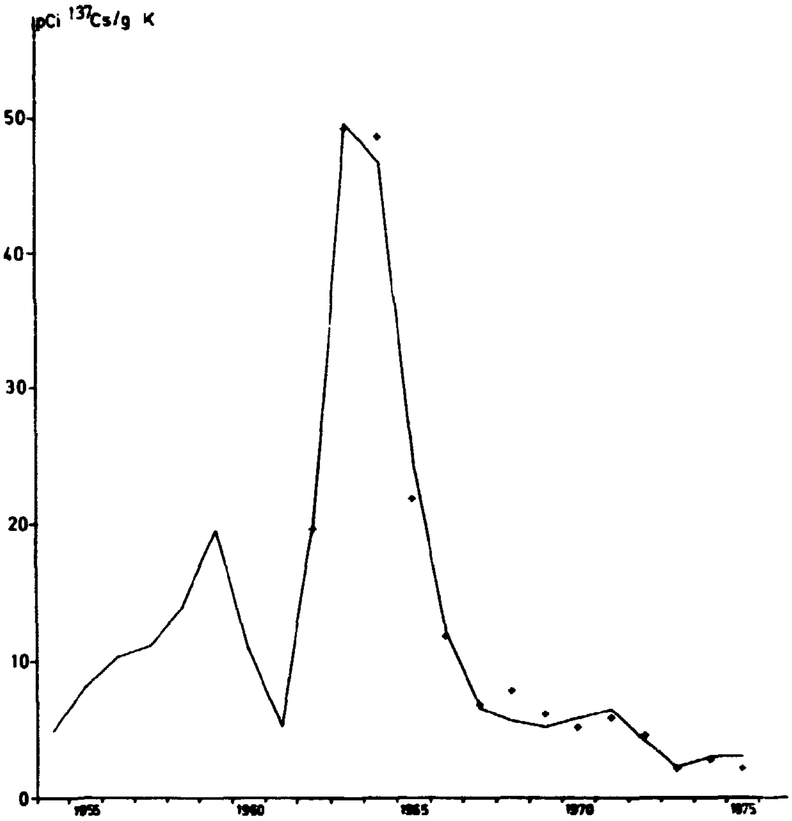

Fig. 5.1.4. A comparison between observed and calculated (curve, cf. appendix C) pCi ^{137}Cs/g K levels in dried milk from the Islands.

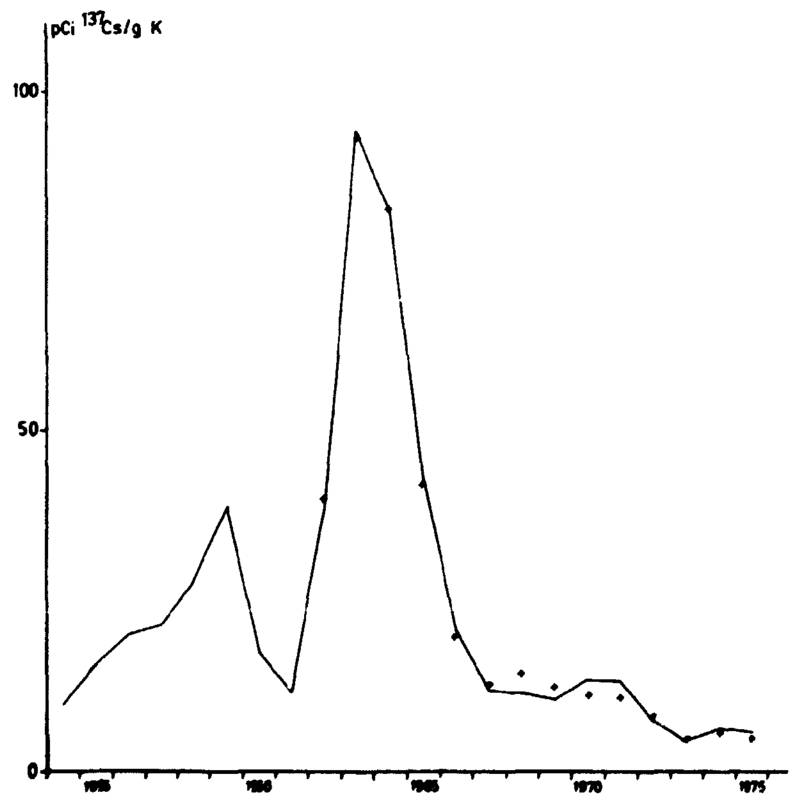

Fig. 5.1.5. A comparison between observed and calculated (curve, cf. appendix C) pCi ^{137}Cs/g K levels in dried milk from Jutland.

5.2. Strontium-90 and Caesium-137 in Fresh Milk from the Entire Contry

The samples of fresh milk were collected in the eight zones and in Copenhagen (cf. fig. 5.2.1) in connection with the total-diet collection (cf. 5.7).

Table 5.2.1 shows the results of the determinations of radiostrontium and ^{137}Cs in consumer milk.

The production-weighted means for ^{90}Sr and ^{137}Cs in Danish consumer milk in 1975 collected in June and December were 4.6 S.U. ($\sim$5.5 pCi ^{90}Sr/l) and 2.9 M.U. or 4.8 pCi ^{137}Cs/l respectively.

As observed previously (except in 1973), the fresh milk showed lower levels for caesium than the corresponding dried milk. Strontium showed a little heigher levels for fresh milk, than the corresponding dried milk.

Table 5.2.1

Strontium-90 and Caesium-137 in fresh milk in 1975

Zone	June 1975			December 1975		
	pCi ^{90}Sr/g Ca	pCi ^{137}Cs/g K	pCi ^{137}Cs/l	pCi ^{90}Sr/g Ca	pCi ^{137}Cs/g K	pCi ^{137}Cs/l
I: N-Jutland	5.3	3.4	5.6	4.2	2.6	4.7
II: E-Jutland	9.1	2.8	4.6	3.3	3.6	5.9
III: W-Jutland	5.1	4.8	7.8	4.4	3.8	6.3
IV: S-Jutland	4.1	1.4	2.2	2.9	1.4 A	2.4 A
V: Funen	2.9	1.7	2.6	2.8	2.8	4.5
VI: Zealand	2.6	2.5	3.9	2.6	[illegible].8 B	1.3 B
VII: Lolland-Falster	2.2	2.2 A	3.5 A	2.4	1.4 A	2.3 A
VIII: Bornholm	3.9	1.8 A	2.9 A	3.8 A	1.3 B	2.1 B
Mean	4.4	2.6	4.1	3.3	2.2	3.7
Copenhagen	3.4	2.2	3.5	4.4	1.7 B	2.7 B
Population-weighted mean	4.6	2.7	4.4	3.6	2.3	3.8
Production-weighted mean	5.7	3.0	4.9	3.5	2.8	4.7

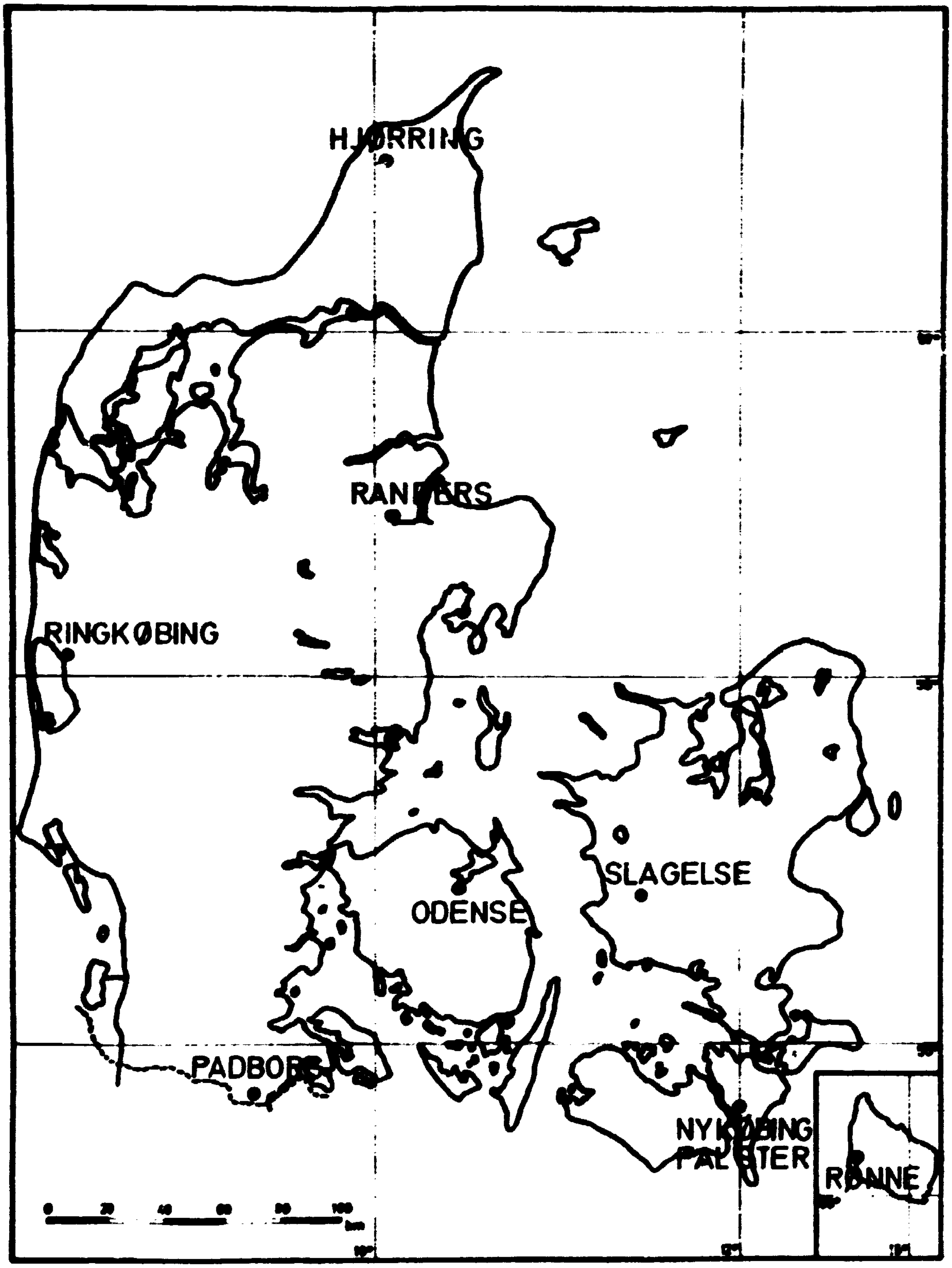

Fig. 5.2.1. Sample locations for fresh milk, bread and total diet.

5.3. Strontium-90 and Caesium-137 in Grain from the Entire Country

As in previous years, grain samples were obtained from the State experimental farms (cf. fig. 4.1.1). Virumgård was replaced by Ledreborg in 1969. Strontium-90 was determined as previously (Risø Report No. 63[1]), and ^{137}Cs was measured on ashed samples by γ-spectrometry on a Ge-detector, five farms were furthermore measured for ^{137}Cs by the AMP-method[27].

Table 5.3.1 shows the measurements of ^{90}Sr in grain in 1975. According to Appendix B, approx. 2/3 of all rye in Denmark is grown in Jutland and 1/3 in the eastern part of the country. As regards wheat, 4/5 is produced in eastern Denmark and 1/5 in Jutland. In the calculation of the means in tables 5.3.1 and 5.3.4.A;Jutland is represented by four rye figures and seven wheat figures, while eastern Denmark contributes nine wheat figures and four rye figures. Thus the means in tables 5.3.1 - 5.3.4 for wheat are higher than the production-weighted means for the country, while the rye means are perhaps too low. Table 5.3.2 gives the analysis of variance of the S. U. figures and table 5.3.3 that of the pCi ^{90}Sr/kg grain figures.

Tables 5.3.2 and 5.3.3 show that the variations in S. U. between species and locations were significant. Rye showed the highest S. U. levels and oats the lowest, while the pCi ^{90}Sr/kg figures were higher in oats than in the other species.

As in previous years, the variation with location was highly significant; the mean pCi ^{90}Sr/kg level for grain from Jutland was 2.2 times that in eastern Denmark.

Table 5.3.1

Strontium-90 in Danish grain in 1975

	Rye		Barley		Wheat		Oats	
	pCi ^{90}Sr/kg	S.U.	pCi ^{90}Sr/kg	S.U.	pCi ^{90}Sr/kg	S.U.	pCi ^{90}Sr/kg	S.U.
Tylstrup	w: 22	w: 85	26	57	s: 17.8	s: 55	47	59
Studsgård	w: 29	w: 103	27	79	w: 39	w: 76	53	62
Ødum	-	-	10.5	24	w: 10.1	w: 32	12.7	14.6
Askov	w: 19.3	w: 58	21	53	w: 19.4 s: 21	w: 59 s: 51	45	47
St. Jyndevad	w: 46	w: 102	41	91	w: 59 s: 36	w: 189 s: 98	54	71
Blangstedgård	w: 10.6	w: 27	17.8	36	w: 17.4	w: 53	28	32
Tystofte	w: 8.2	w: 25	7.9	15.8	w: 8.5 s: 14.1	w: 29 s: 31	21	25
Ledreborg	w: 15.4	w: 17.3	11.2	26	w: 16.1 s: 15.5	w: 47 s: 37	25	20
Abed	-	-	7.4±1.3	17.9±3.1	w:3.4±0.8 s: 4.7	w:13.9±3.4 s: 12.3	11.0	12.4
Åkirkeby	w: 9.5	w: 30	12.3	33	w: 32 s: 11.4	w: 54 s: 30	16.8	16.2
Mean	20	56	18.4	43	20	54	31	36

w: winter variety, s: spring variety.

Table 5.3.2

Analysis of variance of ln S.U. in grain in 1975
(from table 5.3.1)

Variation	SSD	f	s^2	v^2	P
Betw. species	1.028	3	0.343	5.287	>99%
Betw. locations	16.381	9	1.820	28.081	>99.95%
Spec. x loc.	1.620	25	0.065	0.860	-
Remainder	0.452	6	0.075		

Table 5.3.3

Analysis of variance of ln pCi ^{90}Sr/kg grain in 1975
(from table 5.3.1)

Variation	SSD	f	s^2	v^2	P
Betw. species	2.535	3	0.845	14.567	>99.95%
Betw. locations	15.727	9	1.747	30.122	>99.95%
Spec. x loc.	1.450	25	0.058	0.350	-
Remainder	0.995	6	0.166		

Tables 5.3.4 A and 5.3.4 B show the measurements of ^{137}Cs in grain in 1975, table 5.3.5 A the analysis of variance of the M.U. figures and table 5.3.6 A the analysis of variance of the pCi ^{137}Cs/kg grain figures. The ^{137}Cs levels in grain from 1975 were 0.33 times the levels in 1974. The ratio between fall-out in May-August in 1975 and 1974 was 0.38.

Comparing the S.U. levels in grain from the harvest of 1975 with the levels from 1974[1], we find that the 1974 figures are 0.66 times the 1974 levels.

In figs. 5.3.1 - 5.3.16 are shown a comparison between observed and predicted ^{90}Sr and ^{137}Cs levels (cf. Appendix C).

Table 5.3.4.A

Caesium-137 in Danish grain in 1975

	Rye		Barley		Wheat		Oats	
	pCi ^{137}Cs/kg	M.U.	pCi ^{137}Cs/kg	M.U.	pCi ^{137}Cs/kg	M.U.	pCi ^{137}Cs/kg	M.U.
Tylstrup	20	4.0	11.9	2.0	s: 0.9 B	s: 0.2 B	5.0 B	0.9 B
Studsgård	20	4.5	12.6 A	2.6 A	w:33	w: 4.7	34	6.9
Ødum	-	-	3.4 B	0.6 B	w: 3.9 B	w: 0.8 B	29	5.3
Askov	8.6 B	1.5 B	7.9 B	1.4 B	w: 4.9 B s:10.5 A	w: 0.9 B s: 2.1 B	9.9 A	1.7 A
St. Jyndevad	42	6.4	14.9	3.3	w:14.6 s:13.7	w: 3.3 s: 3.0	39	7.1
Blangstedgård	10.5 B	1.7 B	B.D.L.	B.D.L.	w: 8.6	w: 2.0	5.3 B	0.9 B
Tystofte	11.2	2.2	12.8	3.1	w: 9.7 A s:14.2	w: 2.1 A s: 3.4	14.6	2.6
Ledreborg	10.7	2.0	B.D.L.	B.D.L.	w: 3.9 B s:B.D.L.	w: 0.9 B s:B.D.L.	5.3 B	0.9 B
Abed	-	-	8.1 B	1.4 B	w: 8.2 A s:12.7 A	w: 1.7 A s: 2.7 A	12.4	2.0
Åkirkeby	12.7	2.6	10.8 A	2.1 A	w: 3.0 B s: 7.6 A	w: 0.9 B s: 1.9 A	9.8	1.9
Mean	17.0	3.1	8.2	1.65	9.3	1.91	16.4	3.0

w: winter variety, s: spring variety

Table 5.3.4.B

Caesium-137 in Danish grain in 1975
determined by A.M.P. method (pCi/kg)

	Rye	Barley	Wheat	Oats
Tylstrup	15.7	7.9	7.0	13.8
Studsgård	20.8	11.3	28.4	32.5
St. Jyndevad	28.0	8.3 A	w: 11.5 s: 19.4	38.1
Tystofte	7.1 A	7.7	w: 7.6 s: 12.1	B.D.L.
Åkirkeby	7.2 A	9.0	w: 7.8 s: 9.0	7.8

Table 5.3.5.A

Analysis of variance of ln pCi ^{137}Cs/g K in grain in 1975
(from table 5.3.4.A)

Variation	SSD	f	s^2	v^2	P
Betw. species	2.007	3	0.669	1.826	-
Betw. locations	9.357	9	1.040	2.838	>97.5%
Species x loc.	8.060	22	0.366	2.161	-
Remainder	0.848	5	0.170		

Table 5.3.6.A

Analysis of variance of ln pCi ^{137}Cs/kg in grain in 1975
(from table 5.3.4.A)

Variation	SSD	f	s^2	v^2	P
Betw. species	3.281	3	1.094	2.715	-
Betw. locations	9.240	9	1.027	2.549	>95%
Species x loc.	8.861	22	0.403	2.240	-
Remainder	0.899	5	0.180		

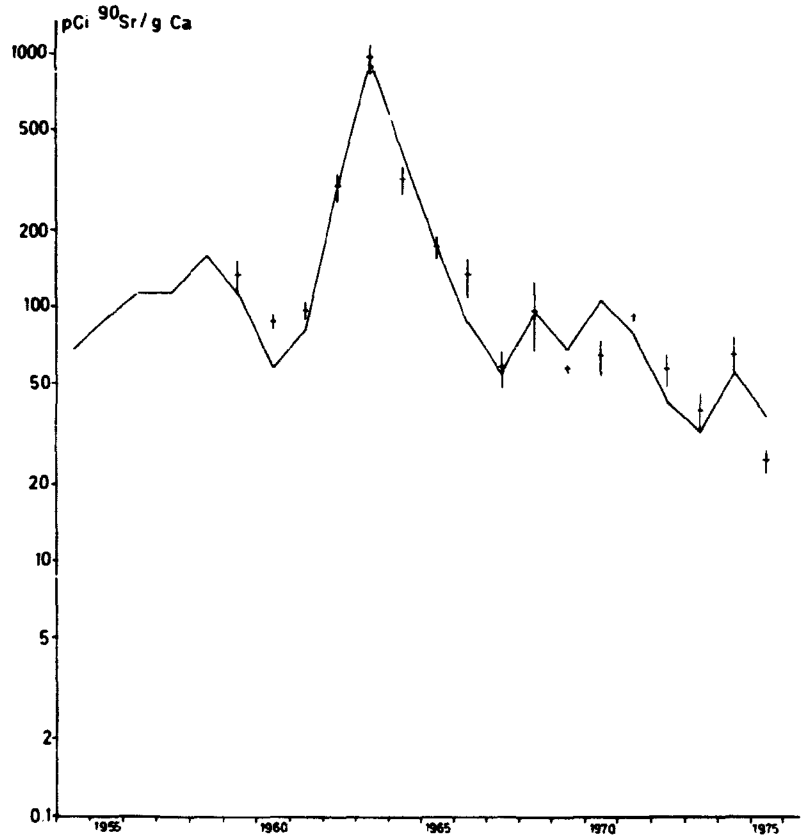

Fig. 5.3.1. A comparison between observed ($\pm$ 1 S. E.) and calculated (curve, cf. appendix C) S. U. -levels in rye from the Islands.

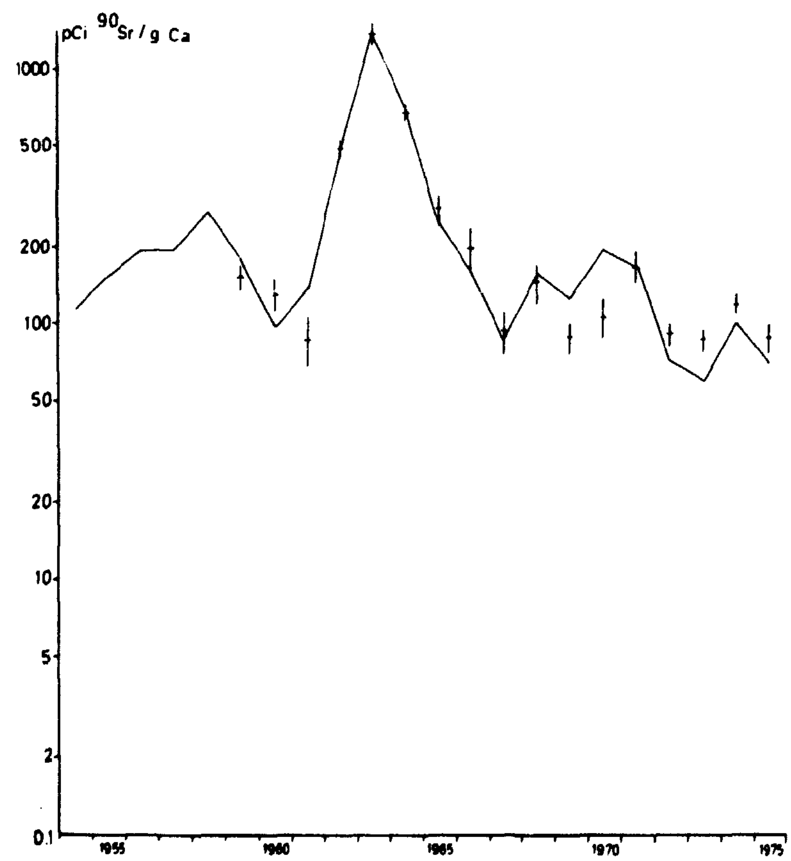

Fig. 5.3.2. A comparison between observed ($\pm$ 1 S. E.) and calculated (curve, cf. appendix C) S. U. -levels in rye from Jutland.

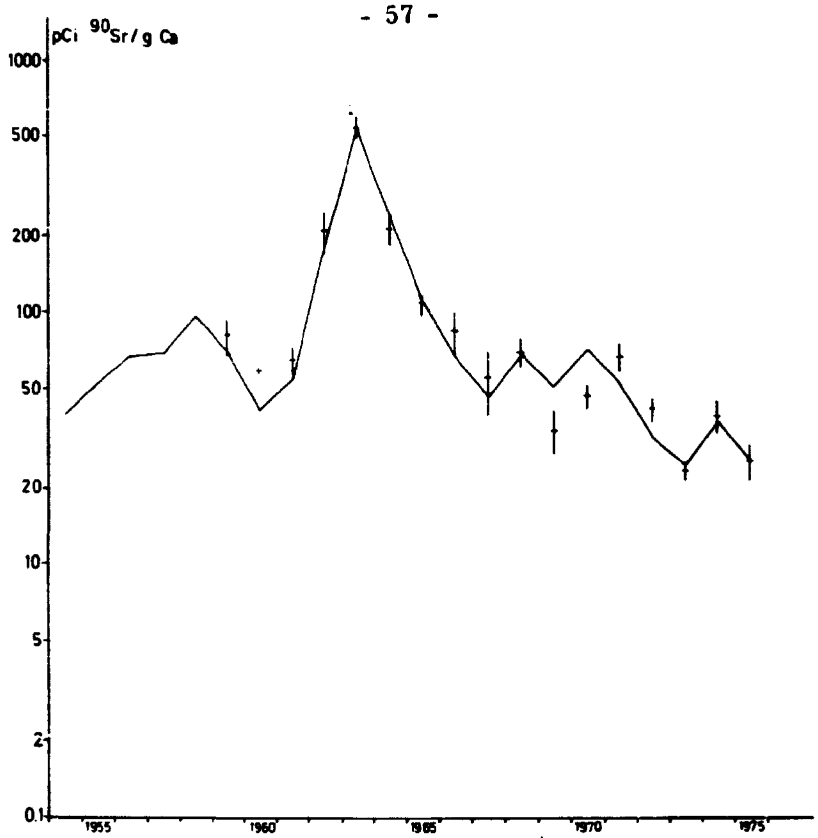

Fig. 5.3.3. A comparison between observed ($\pm$1 S.E.) and calculated (curve, cf. appendix C) S.U.-levels in barley from the Islands.

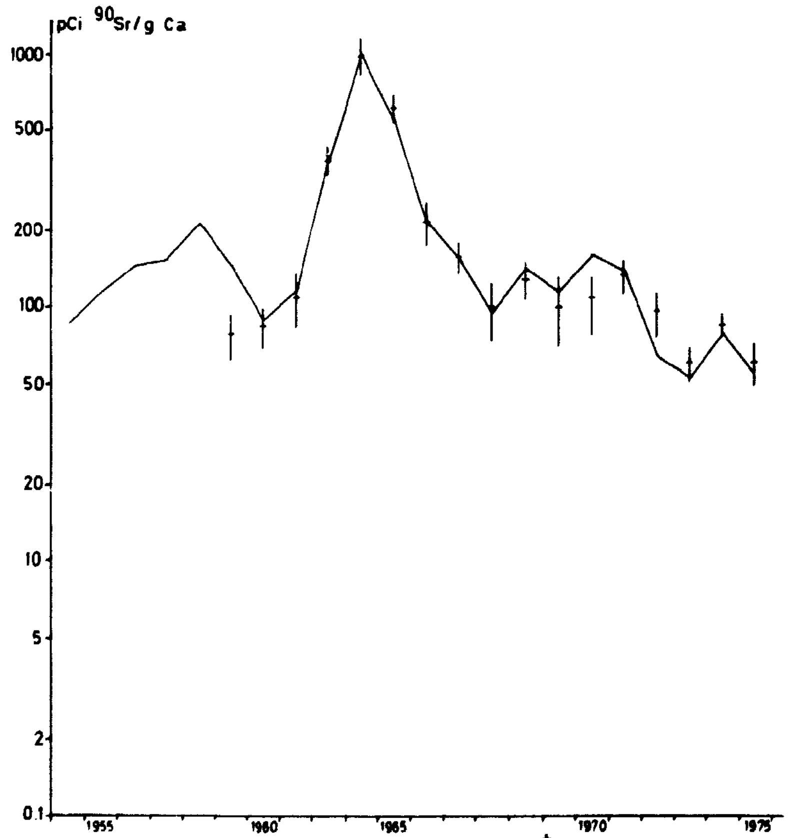

Fig. 5.3.4. A comparison between observed ($\pm$1 S.E.) and calculated (curve, cf. appendix C) S.U.-levels in barley from Jutland.

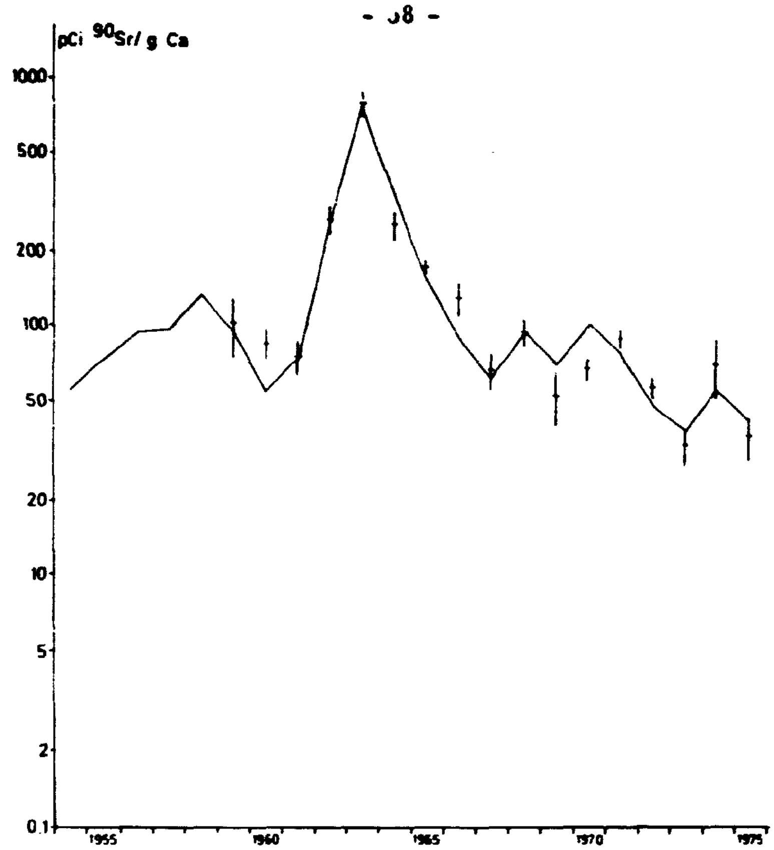

Fig. 5.3.5. A comparison between observed (± 1 S.E.) and calculated (curve, cf. appendix C) S.U.-levels in wheat from the Islands.

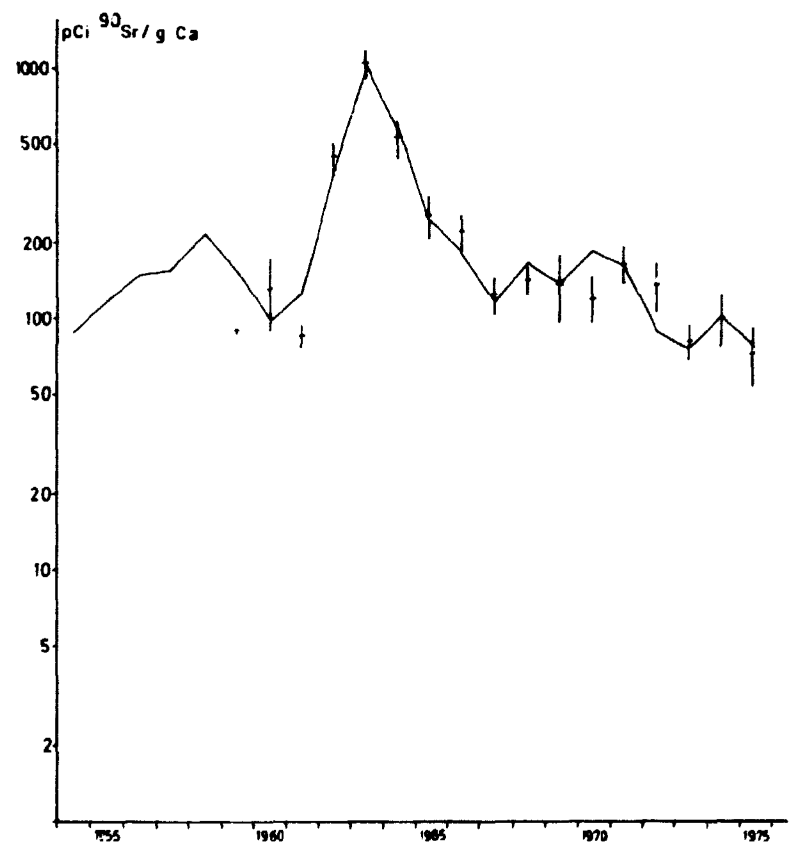

Fig. 5.3.6. A comparison between observed (± 1 S.E.) and calculated (curve, cf. appendix C) S.U.-levels in wheat from Jutland.

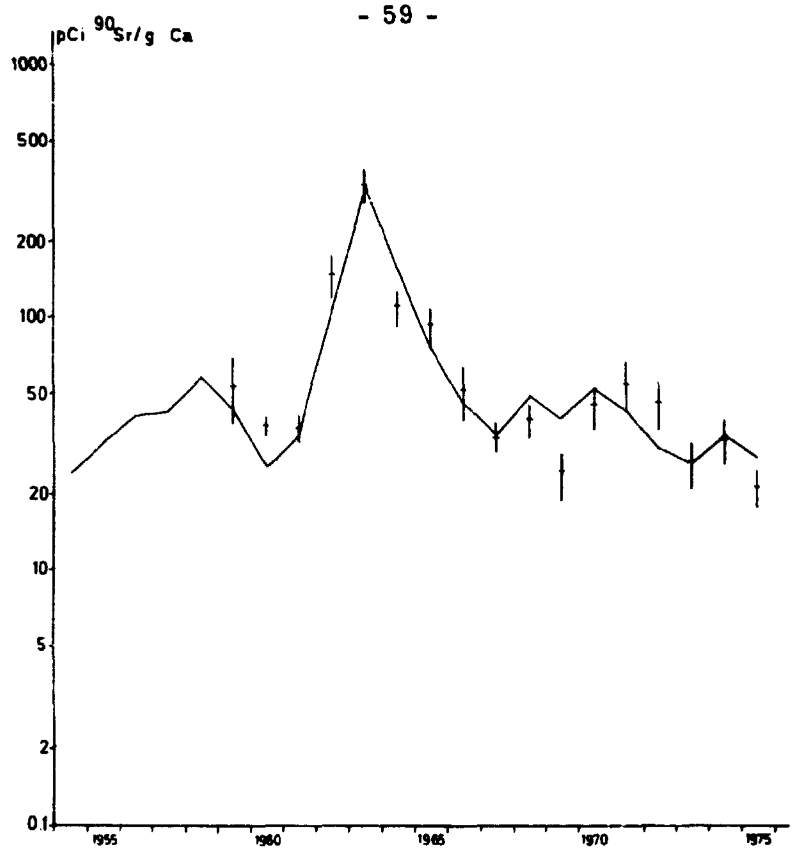

Fig. 5.3.7. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) S.U.-levels in oats from the Islands.

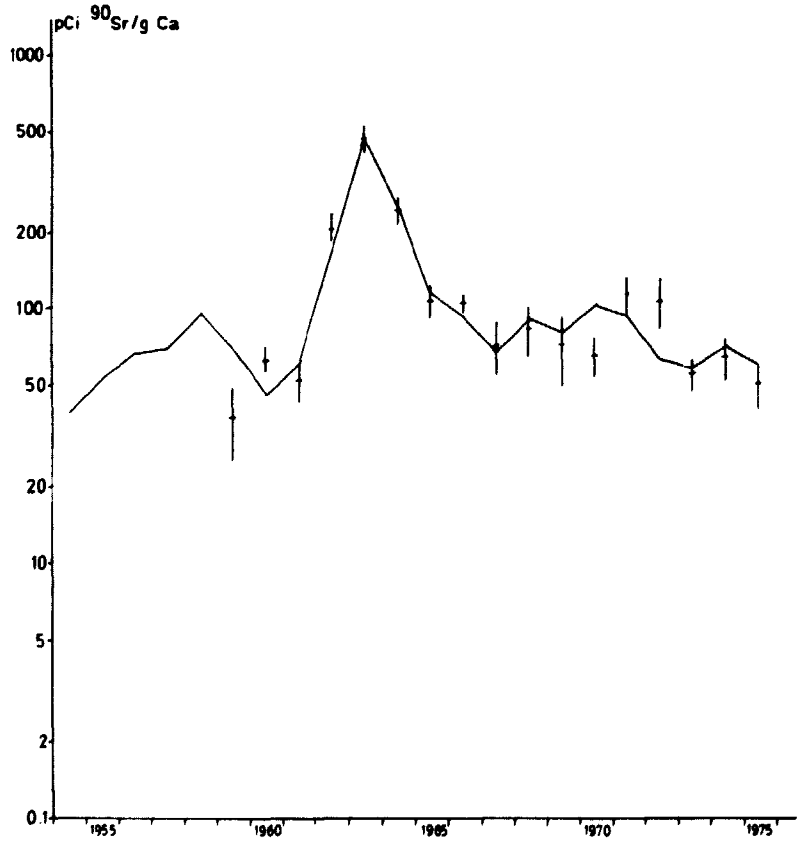

Fig. 5.3.8. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) S.U.-levels in oats from Jutland.

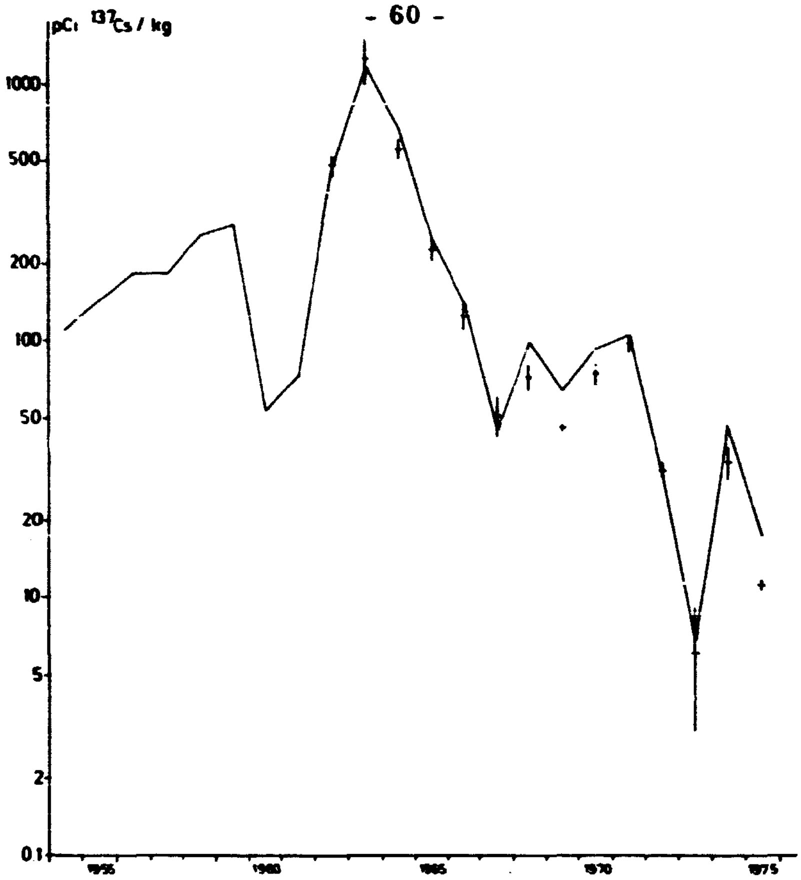

Fig. 5.3.9. A comparison between obser.ed (± 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in rye from the Islands.

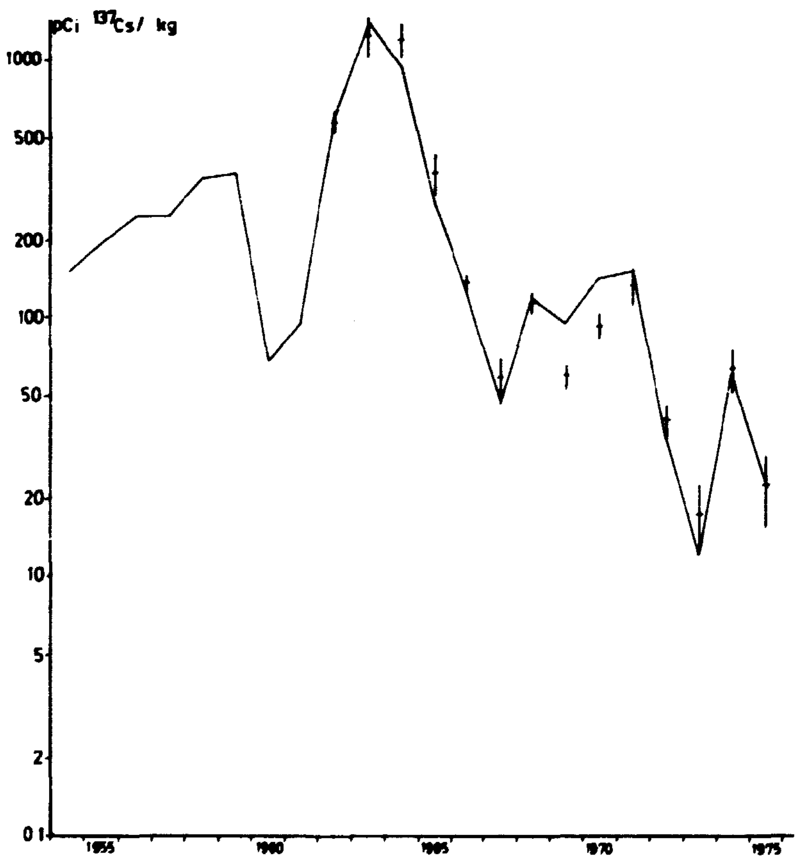

Fig. 5.3.10. A comparison between observed (± 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in rye from Jutland.

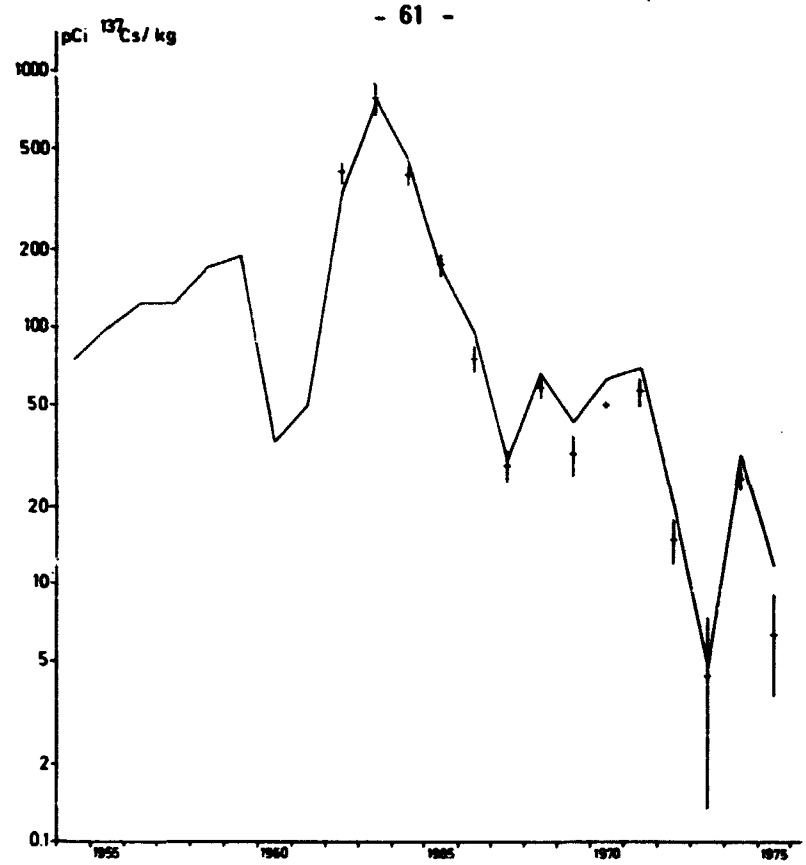

Fig. 5.3.11. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in barley from the Islands.

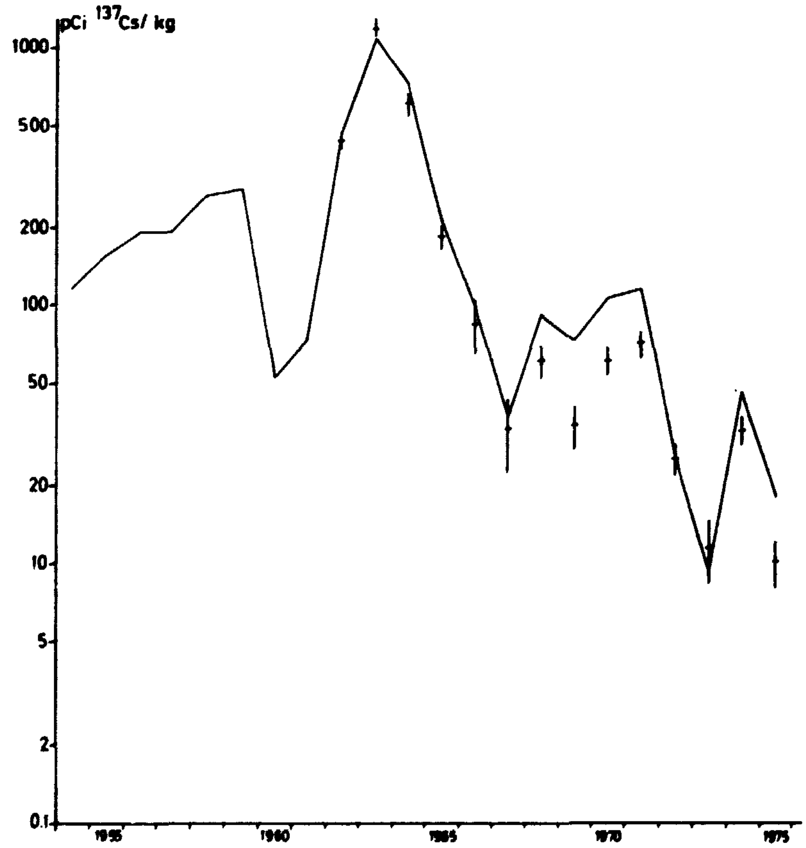

Fig. 5.3.12. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in barley from Jutland.

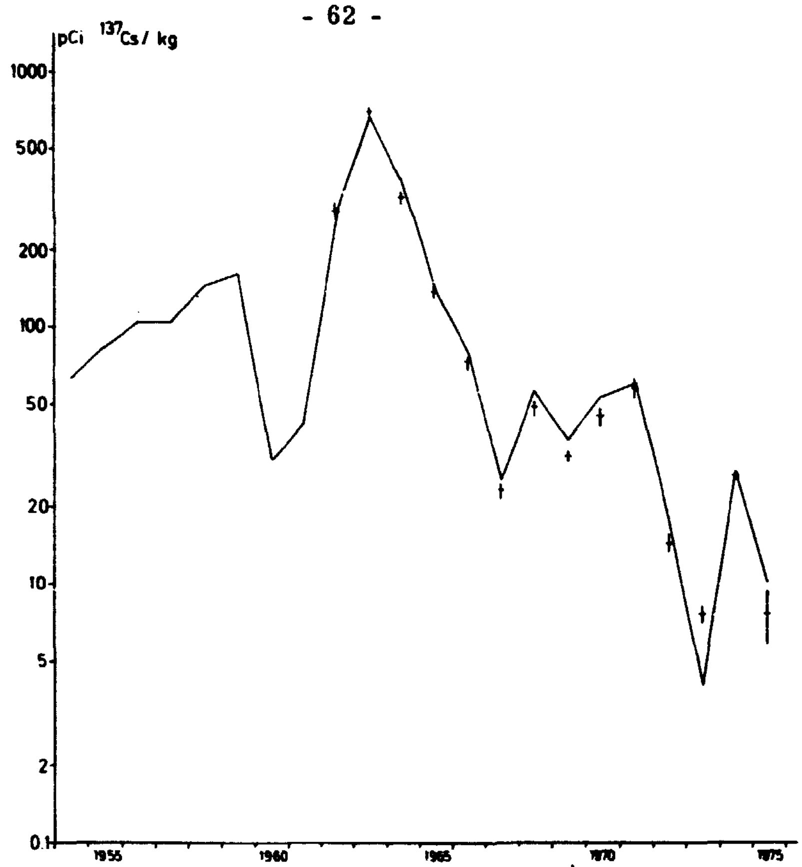

Fig. 5.3.13. A comparison between observed (± 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in wheat from the islands.

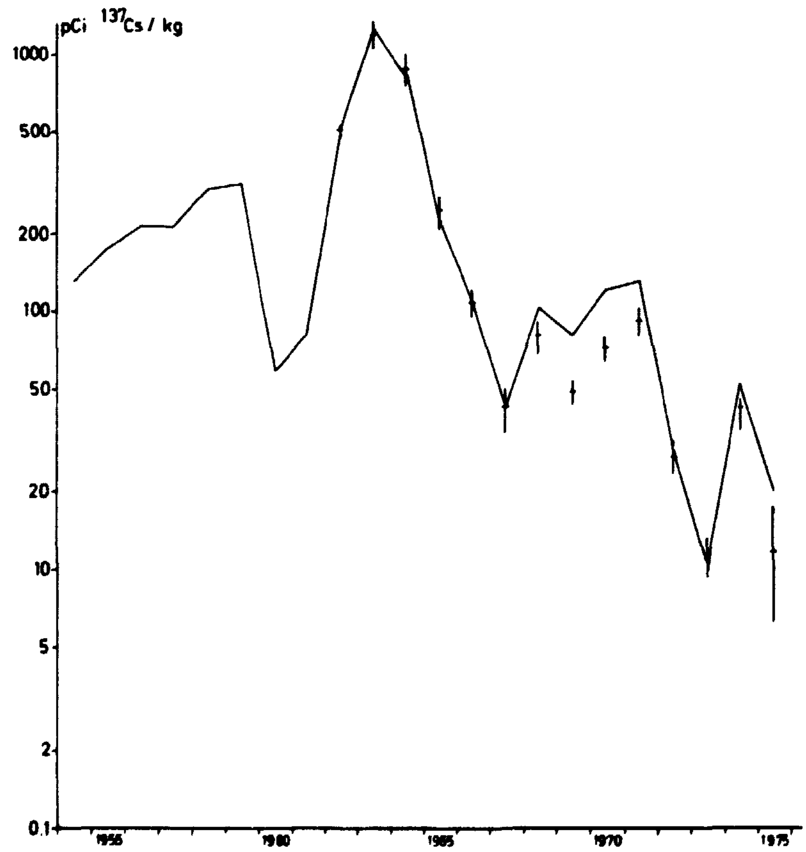

Fig. 5.3.14. A comparison between observed (± 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in wheat from Jutland.

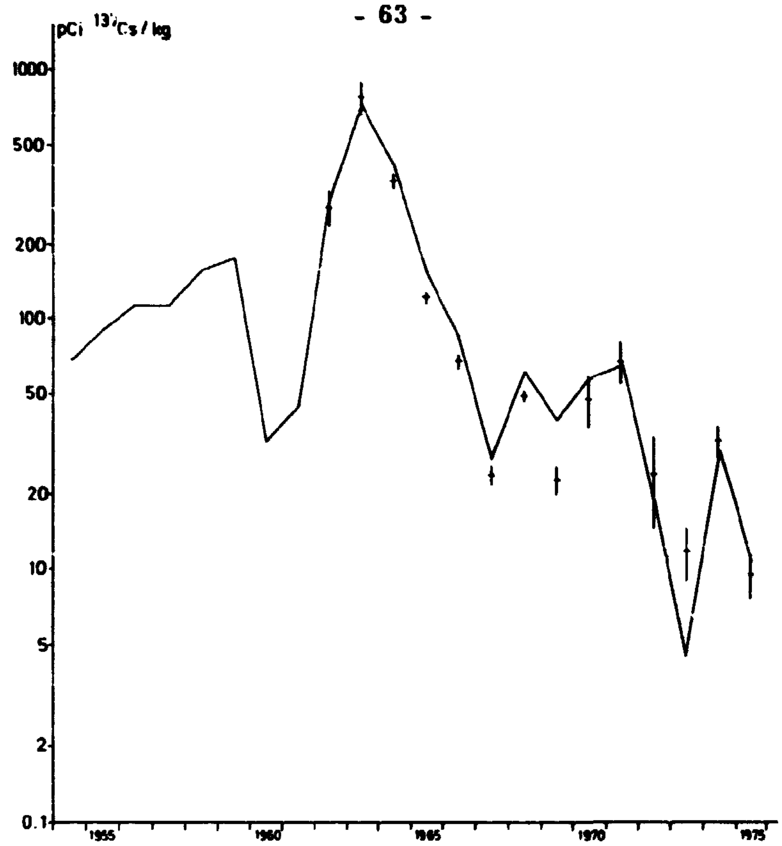

Fig. 5.3.15. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in oats from the Islands.

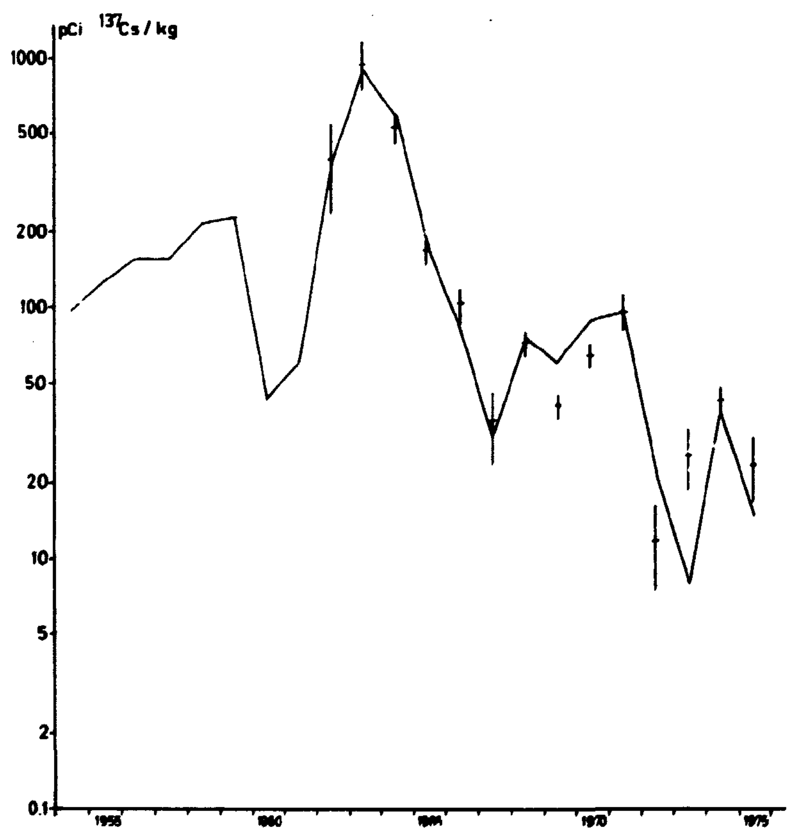

Fig. 5.3.16. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in oats from Jutland.

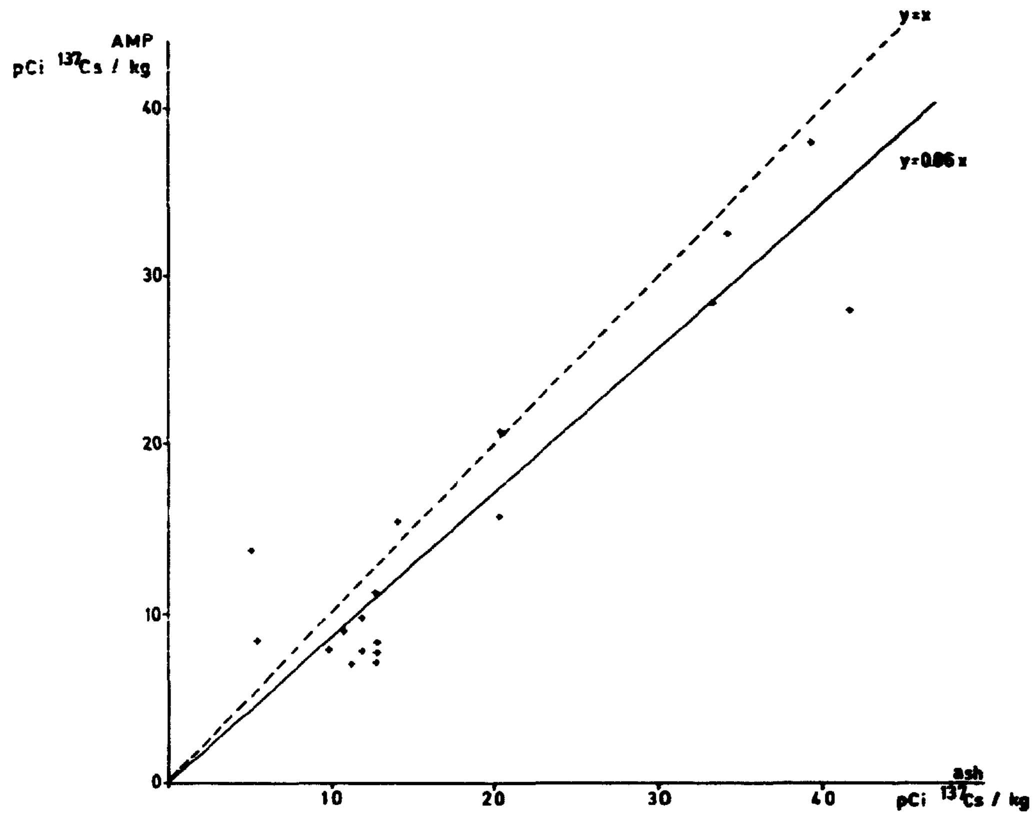

Fig. 5.3.17. A comparison between the ^{137}Cs concentrations in mutual grain samples from 1975 measured by Ge(Li) spectroscopy directly on the ash (abscissa) and on AMP-precipitate (ordinate).

5.4. Strontium-90 and Caesium-137 in Bread from the Entire Country

In 1975, samples of white bread (75% extraction) and dark rye bread (100% extraction) were collected all over the country in June, and ^{90}Sr and ^{137}Cs were determined. The ^{137}Cs determinations were carried out on the ash by Ge γ-spectroscopy.

Tables 5.4.1 and 5.4.2 show the results. It is assumed that 1 kg flour yields approx. 1.35 kg bread[11] and that wheat flour of 75% extraction contains 20% of the ^{90}Sr and 50% of the ^{137}Cs found in wheat grain[1], while rye flour is 100% extraction. Hence we can compare the 1975 bread levels with the 1974 grain levels (cf. table 5.4.3).

Table 5.4.3 shows that the ^{90}Sr and ^{137}Cs levels in bread were in reasonable agreement with the above-mentioned model, except for ^{90}Sr in white bread, where the bread levels were higher than expected.

Table 5.4.1

Strontium-90 in Danish bread in June 1975

Zone		White bread		Rye bread	
		pCi/kg	S.U.	pCi/kg	S.U.
I:	N. Jutland	4.1	2.1	26	8
II:	E. Jutland	9.3	4.7	27	11
III:	W. Jutland	6.1	3.6	23	7
IV:	S. Jutland	5.7	2.6	32	8
V:	Funen	6.6	6.1	20	7
VI:	Zealand	6.1	3.4	16	5
VII:	Lolland-Falster	6.2	3.0	23	9
VIII:	Bornholm	6.6	3.8	18	6
Mean		6.3	3.7	23	8
Copenhagen		5.6	3.5	17	7
Population-weighted mean		6.4	3.8	21	8

Table 5.4.2

Caesium-137 in Danish bread in June 1975

Zone		White bread		Rye bread	
		pCi/kg	M.U.	pCi/kg	M.U.
I:	N. Jutland	12.6	7.8	37	11
II:	E. Jutland	10.0	5.9	41	11
III:	W. Jutland	13.6	9.4	36	11
IV:	S. Jutland	10.1 A	6.3 A	40	9
V:	Funen	11.1	8.0	21	9
VI:	Zealand	9.2	6.8	24	8
VII:	Lolland-Falster	16.9	9.8	42	13
VIII:	Bornholm	6.8 A	4.7 A	34	9
Mean		11.3	7.3	34	10
Copenhagen		9.5 A	6.7 A	38	13
Population-weighted mean		10.8	7.2	35	11

Table 5.4.3

A comparison ^{90}Sr and ^{137}Cs levels in bread and grain in 1975

Nuclide	Species	Bread activity in June 1975 calculated as grain in pCi/kg (cf. text)	Activity in grain from harvest 1974[1)] pCi/kg	"Bread"/grain ratio
^{90}Sr	Wheat	43	31	1.4
	Rye	28	32	0.9
^{137}Cs	Wheat	29	31	0.9
	Rye	47	51	0.9

5.5. Strontium-90 and Caesium-137 in Potatoes from the Entire Country

The samples of potatoes were collected in September from ten of the State experimental farms (cf. fig. 4.1.1) and analysed for ^{90}Sr and ^{137}Cs (γ-spectroscopy of bulked samples of the ash).

Table 5.5.1 shows the ^{90}Sr and ^{137}Cs contents in potatoes. The mean contents for the country were 3.7 pCi ^{90}Sr/kg or 84 S.U. and 6.6 pCi ^{137}Cs/kg or 1.3 M.U. The levels were not significantly different from those of 1974.

The mean of the $^{137}Cs/^{90}Sr$ ratios (pCi/kg figures) was 2.0 (in 1974: 2.0, in 1973: 1.4, in 1972: 1.7, in 1971: 3.1, in 1970: 3.8, in 1969: 1.8, in 1968: 2.6, in 1967: 2.1, in 1966: 2.6, in 1965: 6, and in 1964: 9).

Table 5.5.1

Strontium-90 and Caesium-137 in Danish potatoes in 1975

	pCi ^{90}Sr/kg	S.U.	pCi ^{137}Cs/kg	M.U.
Tylstrup	3.2±0.4	94±15		
Studsgård	4.4±0.4	78± 6		
Ødum	2.4±0.2	56± 8	7.8	1.6
Askov	5.8	105		
St. Jyndevad	3.7	62		
Blangstedgård	2.2±0.1	63± 5		
Tystofte	4.5	25*		
Ledreborg	2.3±0.1	48± 1	5.5	1.0
Abed	3.0±0.2	144±14		
Rønne	5.1	166		
Mean	3.7	84	6.6	1.3

*two Ca-determinations

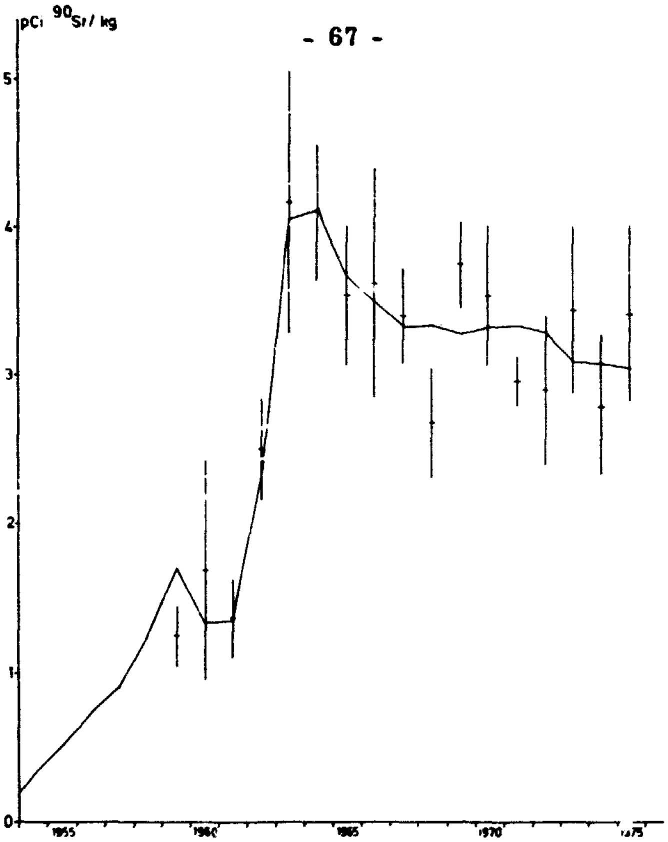

Fig. 5.5.1. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{90}Sr/kg levels in potatoes from the Islands.

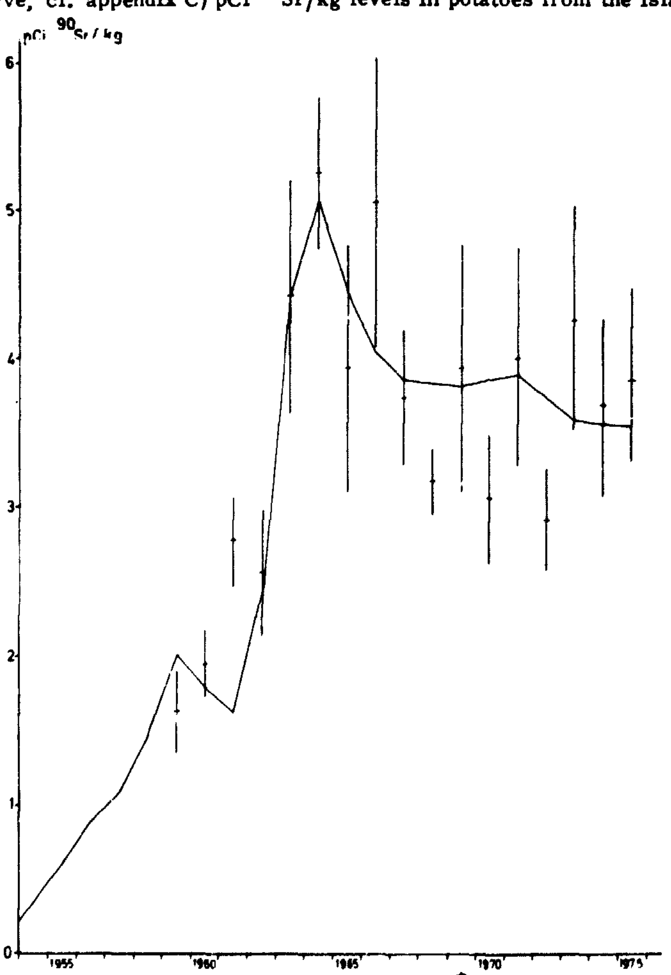

Fig. 5.5.2. A comparis n between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{90}Sr/kg levels in potatoes from Jutland.

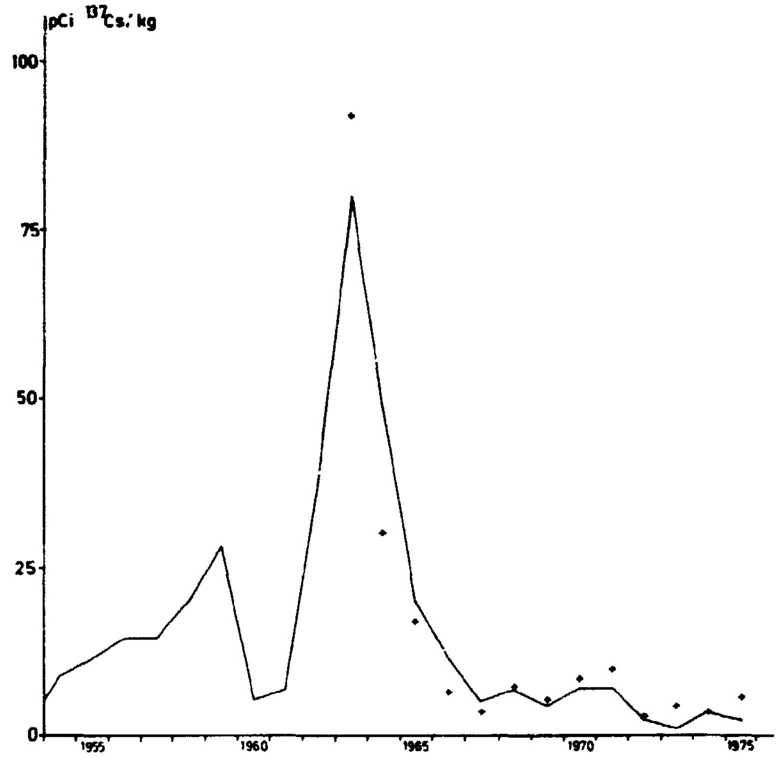

Fig. 5.5.3. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in potatoes from the Islands.

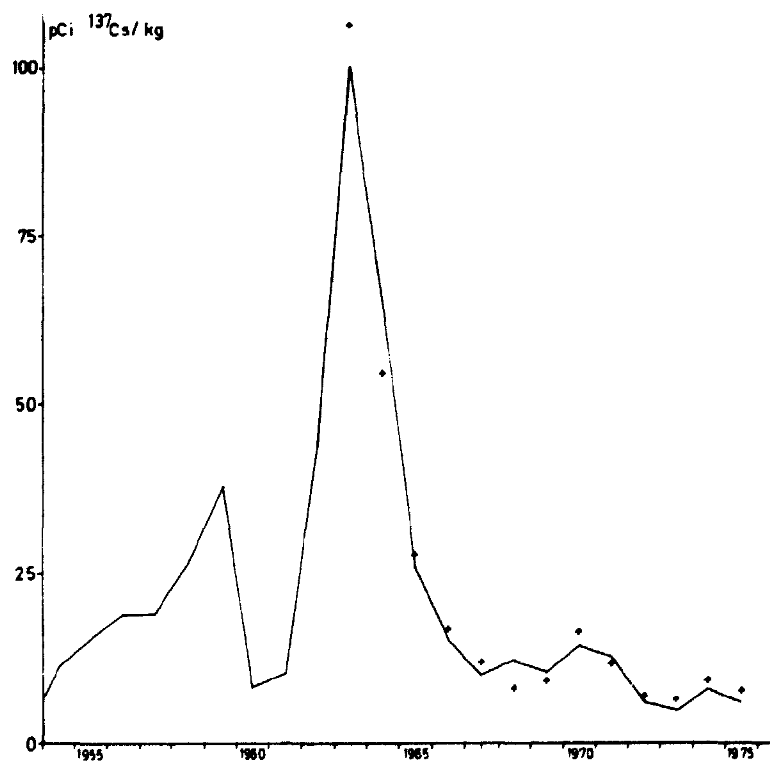

Fig. 5.5.4. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in potatoes from Jutland.

5.6. Strontium-90 and Caesium-137 in Vegetables and Fruits from the Entire Country

In 1975, as in previous years, vegetables and fruits were collected in September and December from eight larger provincial towns, one in each of the eight zones, and from Copenhagen.

The samples were collected in the autumn.

The γ-measurements were performed on bulked ash samples representing the entire country (cf. table 5.6.4). Tables 5.6.1 - 5.6.3 show the results and the analysis of variance of the ^{90}Sr determinations.

The variations between species were highly significant. The highest ^{90}Sr levels (pCi/kg) were found in carrot, the lowest in apple. The variation between locations was probably significant, Lolland-Falster showed lower levels than Jutland.

Table 5.6.1

Strontium-90 in vegetables and fruits in 1975

Zone	Cabbage		Carrot		Apple	
	pCi/kg	S.U.	pCi/kg	S.U.	pCi/kg	S.U.
I: N. Jutland	24	58	23	75	1.04	29
II: E. Jutland	17.9	36	25	80	2.5	56
III: W. Jutland	8.8	22	6.4	21	1.05	28
IV: S. Jutland	11.0	23	20	65	0.82	21
V: Funen	18.0	34	13.0	35	0.88	23
VI: Zealand	8.0	11.6	4.9	16.4	1.37	29
VII: Lolland-Falster	6.3	12.0	3.5	11.3	0.55	16.7
VIII: Bornholm	13.4	29	65	149	1.48	27
Mean	13.4	28	20	57	1.21	29
Copenhagen	9.2	16.8	16.0	50	2.3	74
Population-weighted mean	12.7	26	15.3	48	1.66	45

Table 5.6.2

Analysis of variance of ln pCi ^{90}Sr/kg in vegetables and fruits in 1975
(from table 5.6.1)

Variation	SSD	f	s^2	v^2	P
Betw. species	34.338	2	17.169	68.483	>99.95%
Betw. locations	6.664	8	0.833	3.323	>97.5%
Remainder	4.011	16	0.251		

Table 5.6.3

Analysis of variance of ln S.U. in vegetables and fruits in 1975
(from table 5.6.1)

Variation	SSD	f	s^2	v^2	P
Betw. species	1.362	2	0.681	2.722	-
Betw. locations	6.427	8	0.803	3.212	>97.5%
Remainder	4.003	16	0.250		

Table 5.6.4

Caesium-137 in vegetables and fruits in 1975

	Cabbage	Carrot	Apple
pCi/kg	3.5	2.0 A	2.1
pCi/g K	1.4	0.7 A	1.5

Table 5.6.5

Calculated ^{90}Sr and ^{137}Cs mean levels in vegetables in 1975

Daily intake in g	Species	pCi ^{90}Sr per kg	S.U.	pCi ^{137}Cs per kg	M.U.
50	Leafy vegetables (cabbage)	12.7	26	3.5	1.4
30	Root vegetables (carrot, onion)	15.3	48	2.0	0.7
40	Pea	(4.5)	(17.6)	(3.7)	(0.7)
120	Vegetable total	10.6	29	3.2	1.0

The ^{90}Sr levels in peas are those found in 1973.

The ^{137}Cs levels in peas are those found in 1974.

Figures 5.6.1 - 5.6.4 show the country-wide mean pCi ^{90}Sr kg^{-1} levels in cabbage (white and red) and in carrots collected since 1961 compared with the predicted levels (cf. Appendix C).

The ^{90}Sr levels in cabbage and carrots depend primarily on the ^{90}Sr activity in the soil; during the last years approx. 95% of the ^{90}Sr came from the accumulated ^{90}Sr in the soil. The relatively constant levels since 1966 are in accordance with the almost constant soil levels (cf. 4.2) and support the statement in Appendix C that the availability of the ^{90}Sr in the soil for root uptake does not decrease so rapidly as suspected in 1971.

Figures 5.6.5 - 5.6.6 show the corresponding curve for ^{137}Cs in cabbage and carrots. It is evident that ^{137}Cs in vegetables, unlike ^{90}Sr, depends strongly on the fall-out rate. It also appears that the levels in cabbage and carrots are similar, implying that the ^{137}Cs is translocated in carrots from the parts above the soil to the roots.

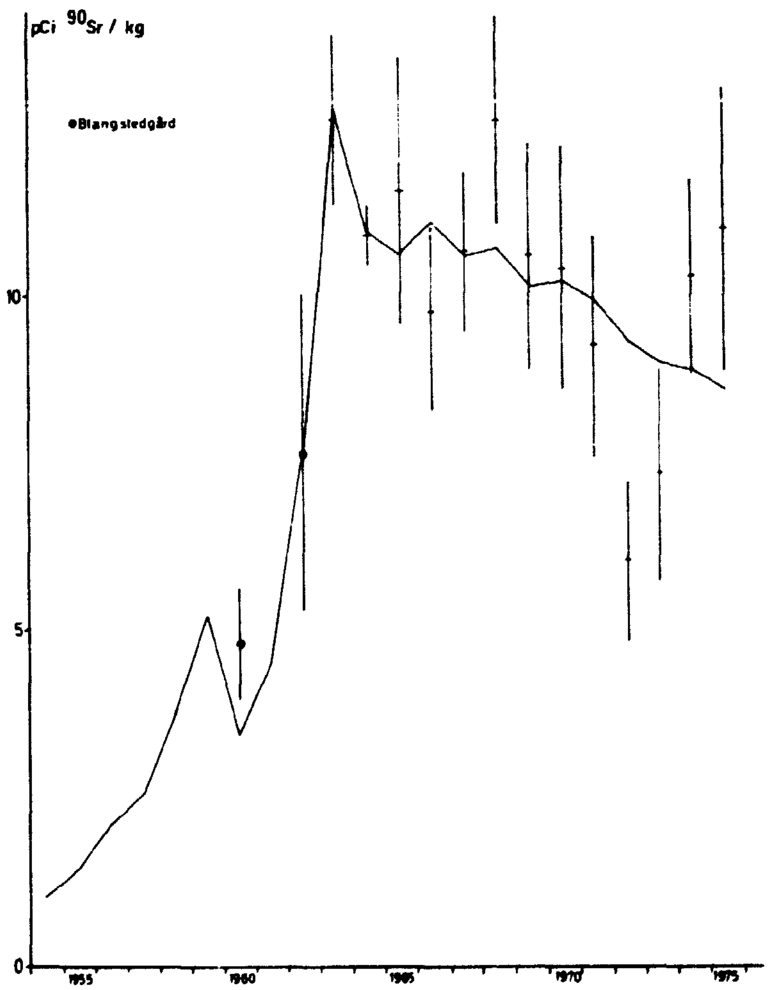

Fig. 5.6.1. A comparison between observed (± 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{90}Sr/kg levels in white cabbage from the Islands.

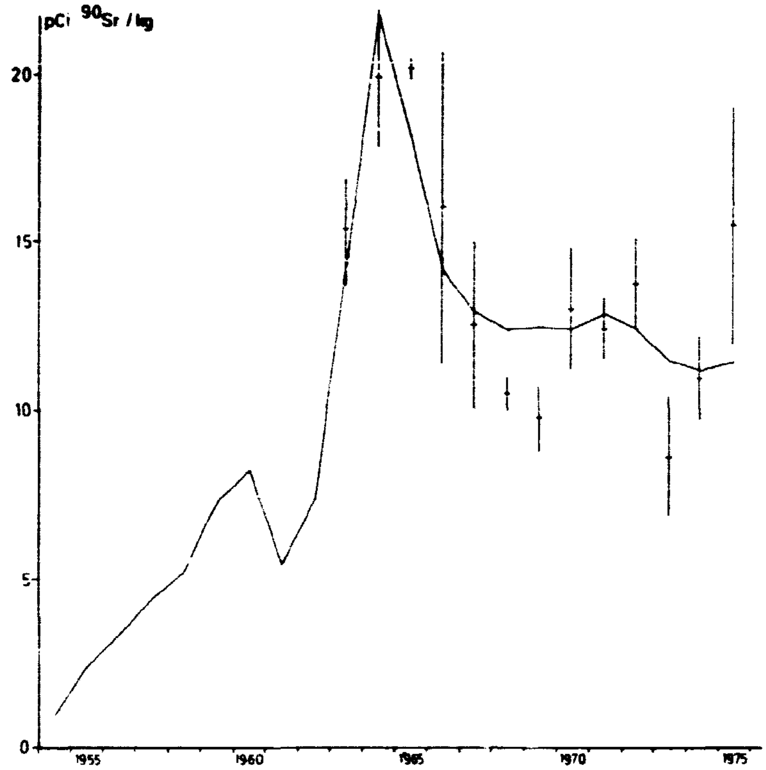

Fig. 5.6.2. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{90}Sr/kg levels in white cabbage from Jutland.

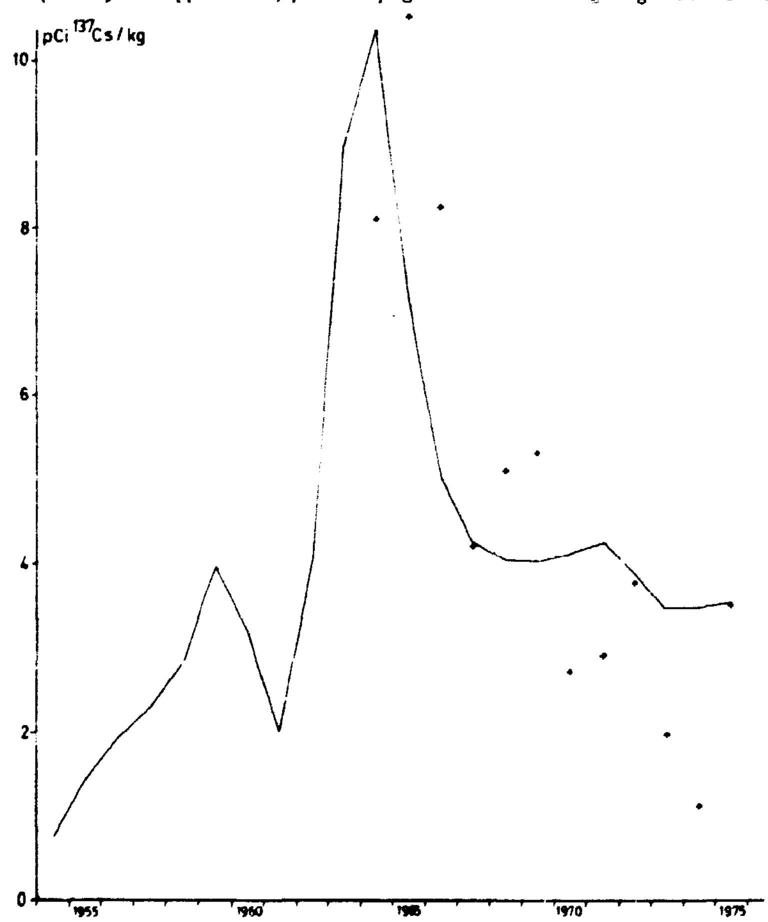

Fig. 5.6.3. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in white cabbage from Denmark.

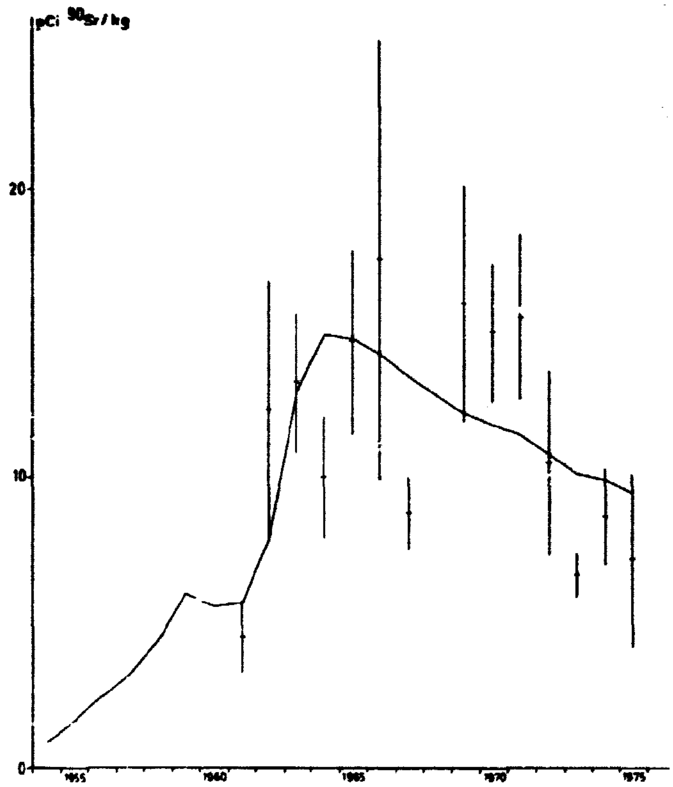

Fig. 5.6.4. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{90}Sr/kg levels in carrots from the Islands.

Table 5.6.5 shows a calculation of the mean contents of ^{90}Sr and ^{137}Cs in Danish vegetables collected in 1975, (^{90}Sr in peas was taken to be the same as the 1973 figures). The levels are the population-weighted means calculated in tables 5.6.1 - 5.6.4.

The 1975 levels in Danish fruit were calculated from apples and the mean levels in Danish fruit were thus 1.7 pCi ^{90}Sr/kg and 2.1 pCi ^{137}Cs/kg.

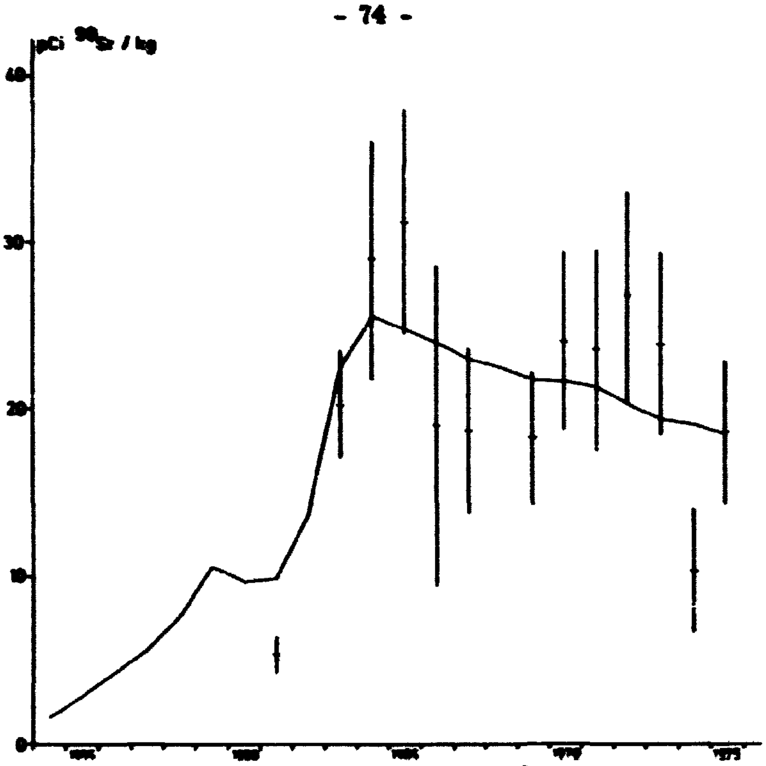

Fig. 5.6.5. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{90}Sr/kg levels in carrots from Jutland.

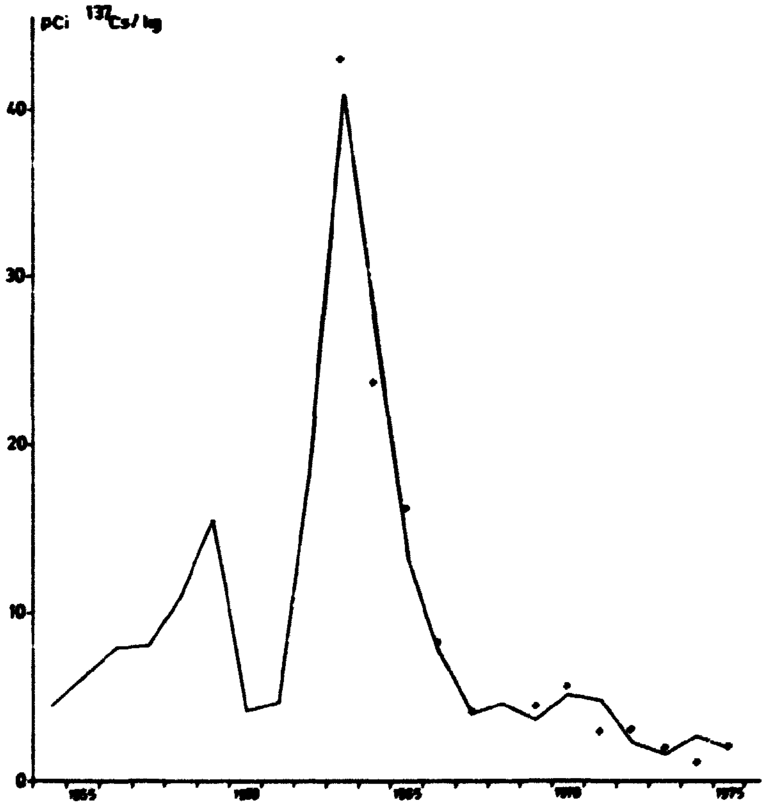

Fig. 5.6.6. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in carrots from Denmark.

5.7. Strontium-90 and Caesium-137 in Total Diet from the Entire Country

In 1975 total-food samples representing an average Danish diet according to E. Hoff-Jørgensen (cf. Appendix B in Risø Report No. 63[1]) were collected from eight towns each representing one of the eight zones (cf. fig. 5.2.1) and from Copenhagen. The sampling took place as previously in June and December.

Table 5.7.1

Strontium-90 and Caesium-137 in Danish total diet collected in June 1975

Zone	pCi ^{90}Sr/g Ca	pCi ^{90}Sr/day	g Ca/day	pCi ^{137}Cs/g K	pCi ^{137}Cs/day
I: N. Jutland	6.7±0.6	10.5±0.8	1.56±0.01	4.9	17.6
II: E. Jutland	6.3±0.2	9.6±0.3	1.53±0.01	4.1	17.0
III: W. Jutland	5.8±0.0	8.9±0.1	1.52±0.01	5.0	16.6
IV: S. Jutland	5.9±0.3	10.1±0.4	1.71±0.04	4.2	18.6
V: Funen	7.0±0.0	10.6±0.0	1.53±0.01	3.6	13.0
VI: Zealand	6.8±0.3	11.2±0.9	1.64±0.06	3.8	15.1
VII: Lolland-Falster	6.5±0.5	9.8±0.3	1.52±0.07	6.1	26.6
VIII: Bornholm	6.7±0.3	10.8±0.4	1.61±0.00	5.7	20.2
Mean	6.5	10.2	1.58	4.7	18.1
Copenhagen	7.2±0.7	11.2±1.1	1.55±0.01	5.3	20.6
Population-weighted mean	6.7	10.4	1.57	4.6	17.7
Relative error due to analysis	9%	8%	3%		

Table 5.7.2

Strontium-90 and Caesium-137 in Danish total diet collected in December 1975

Zone	pCi ^{90}Sr/g Ca	pCi ^{90}Sr/day	g Ca/day	pCi ^{137}Cs/g K	pCi ^{137}Cs/day
I: N. Jutland	6.6±0.2	11.4±0.1	1.72±0.06	2.9	11.9
II. E. Jutland	5.2±0.2	9.4±0.5	1.78±0.03	2.1	8.1
III: W. Jutland	6.2±0.1	10.9±0.2	1.77±0.05	3.5	13.0
IV: S. Jutland	5.4±0.3	9.2±0.5	1.72±0.01	3.1 A	11.6 A
V: Funen	5.9±0.1	10.2±0.1	1.74±0.01	3.4	13.4
VI: Zealand	4.2±0.0	8.1±0.1	1.89±0.03	2.5	10.9
VII: Lolland-Falster	4.6±0.1	7.8±0.2	1.68±0.01	3.4	14.4
VIII: Bornholm	5.6±0.2	9.0±0.2	1.63±0.01	1.8 A	6.9 A
Mean	5.5	9.5	1.74	2.8	11.3
Copenhagen	4.6±0.1	8.9±0.1	1.87±0.06	3.1	12.1
Population-weighted mean	5.2	9.5	1.81	2.9	11.5
Relative error due to analysis	4%	4%	3%		

Tables 5.7.1 and 5.7.2 show the results. As in previous years, the variation between locations was significant. The S.U. levels in the total diet were approx. 50% higher in Jutland than in eastern Denmark.

Figures 5.7.1 - 5.7.4 show the zone mean levels (not population-weighted) of S.U. and M.U. in total diet compared with the predicted values (cf. Appendix C).

The 1975 levels in total diet were lower than the 1974 levels.

From the total-diet sampling it is possible to estimate the mean levels of ^{90}Sr and ^{137}Cs in the Danish diet in 1975. For the period January-April 1975 the ^{90}Sr level in the total diet is assumed to have been equal to that measured in December 1973, Risø Report No. 305[1]. For the period May-September we assume the level to have corresponded to that measured in June 1975. The December 1974 figures is taken to represent the last three months of the year. The population-weighted mean of ^{90}Sr in total-diet samples was 7.0 pCi ^{90}Sr/g Ca in December 1974. Hence the mean content in the total diet in 1975 was 6.4 pCi ^{90}Sr/g Ca or 11 pCi ^{90}Sr/day.

In a similar way the ^{137}Cs content in the Danish diet in 1975 was estimated to be 18 pCi ^{137}Cs/day or 4.8 pCi ^{137}Cs/g K.

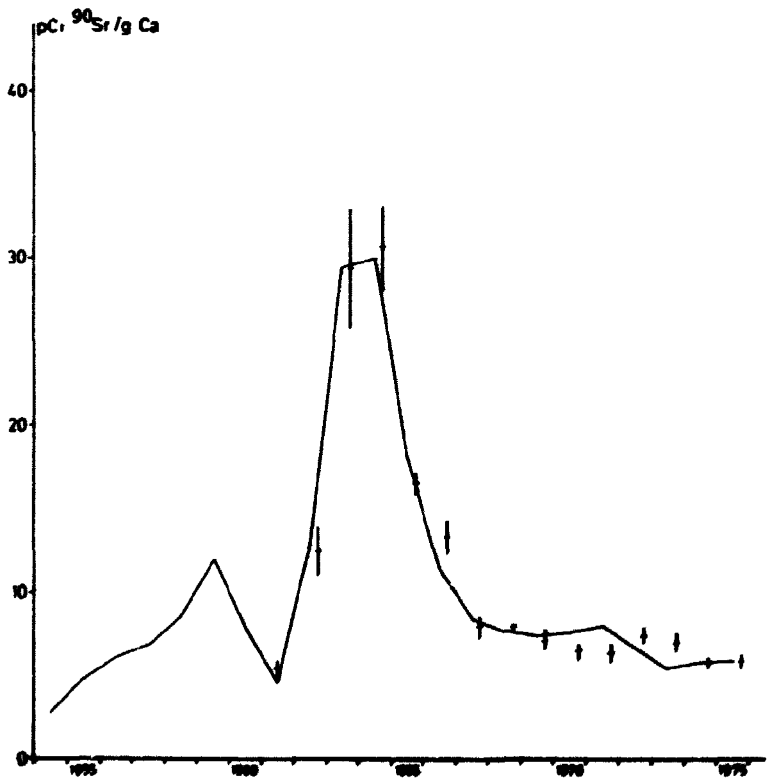

Fig. 5.7.1. A comparison between observed (± 1 S.E.) and calculated (curve, cf. appendix C) S.U.-levels in total diet from the Islands.

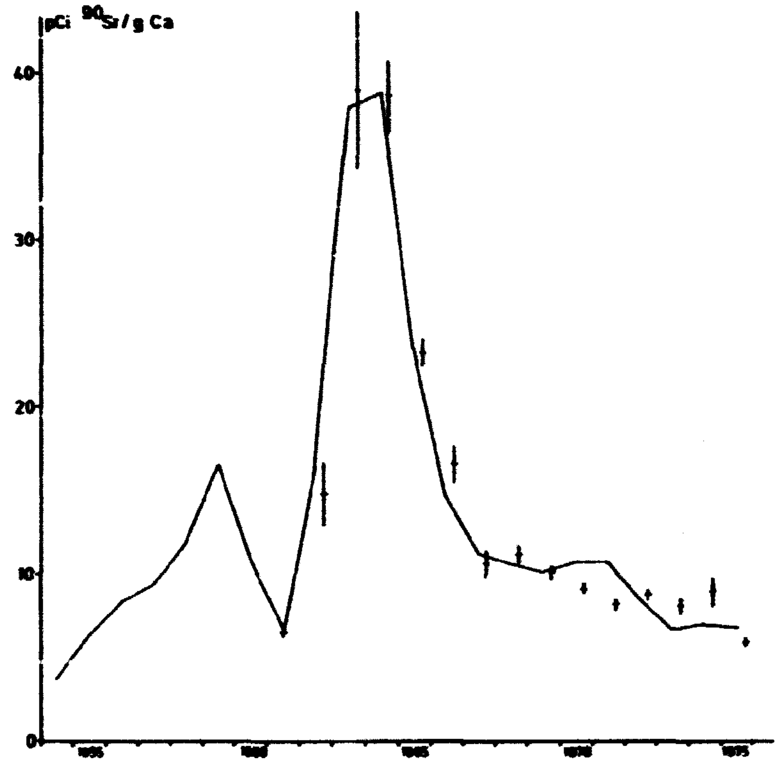

Fig. 5.7.2. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) S.U.-levels in total diet from Jutland.

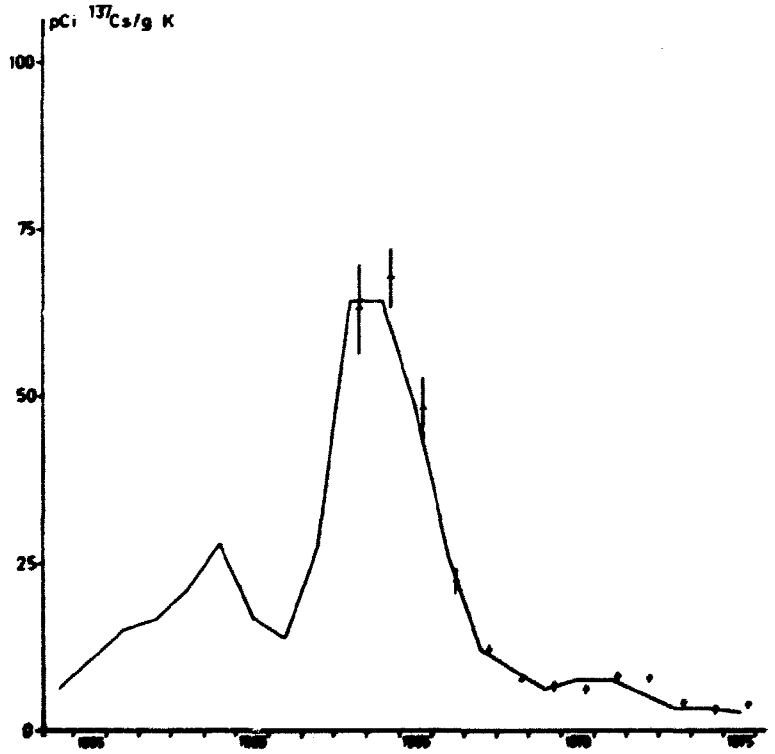

Fig. 5.7.3. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/g K levels in total diet from the Islands.

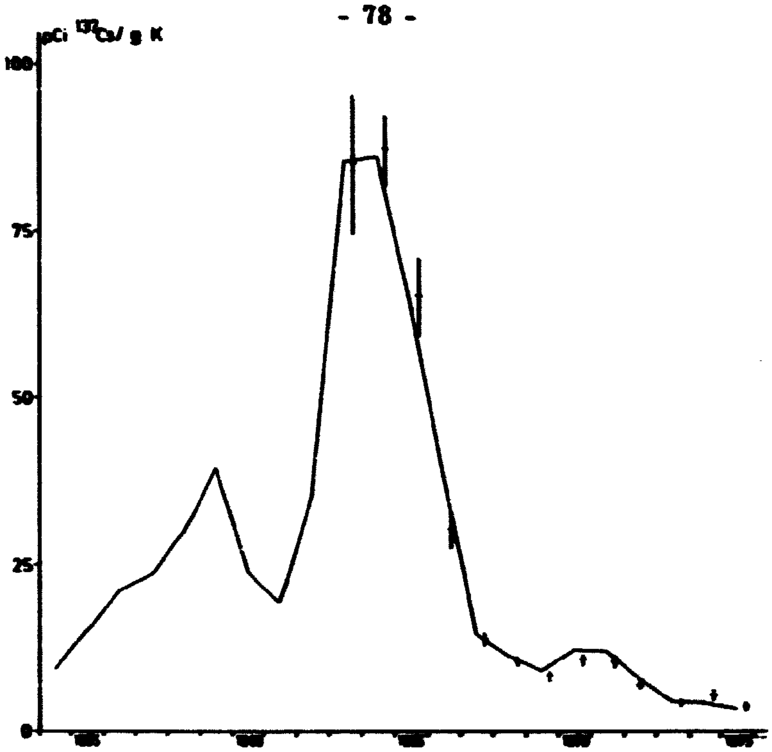

Fig. 5.7.4. A comparison between observed (± 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/g K levels in total diet from Jutland.

5.8. Strontium-90 and Caesium-137 in Miscellaneous Foodstuffs

5.8.1. Strontium-90 and Caesium-137 in Meat

Pork and beef samples were collected in Copenhagen in three large shops in March, June, September, and November. Table 5.8.1 shows the results. Figures 5.8.1.1 - 5.8.1.2 show a comparison between observed and predicted levels (cf. Appendix C).

Table 5.8.1

Strontium-90 and Caesium-137 in pork and beef from Copenhagen in 1975

Species	Unit	March	June	Sep.	Nov.	Mean
Pork	pCi ^{90}Sr/kg	1.15	0.63 A	0.33 B	1.17	0.82
	pCi ^{90}Sr/g Ca	17	10.4 A	4.9 B	7.9	10.0
	pCi ^{137}Cs/kg	25	56	(35)	14.4 A	33
	pCi ^{137}Cs/g K	7.6	18.0	(11)	4.6 A	10.3
Beef	pCi ^{90}Sr/kg	0.49 B	0.95 B	0.76 B	0.37 B	0.64
	pCi ^{90}Sr/g Ca	7.5 B	13.3 B	9.8 B	3.4 B	8.5
	pCi ^{137}Cs/kg	11.2 B	25 A	6.9 A	45	22
	pCi ^{137}Cs/g K	3.5 B	6.6 A	2.4 A	14.3	6.7

Figures in brackets the mean of June and November

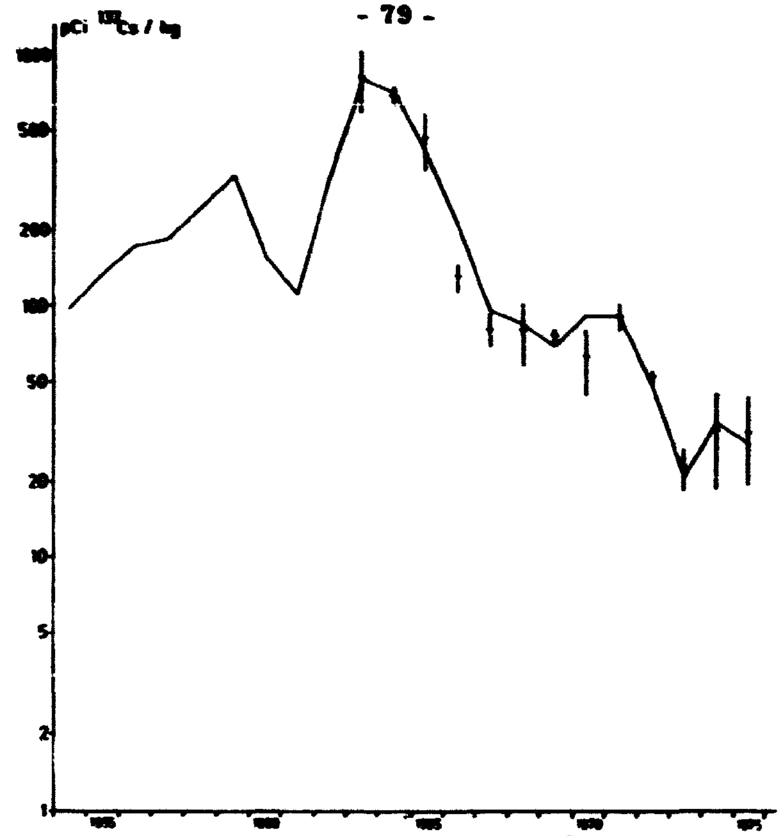

Fig. 5.8.1.1. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve cf. appendix C) pCi ^{137}Cs/kg levels in pork from Denmark.

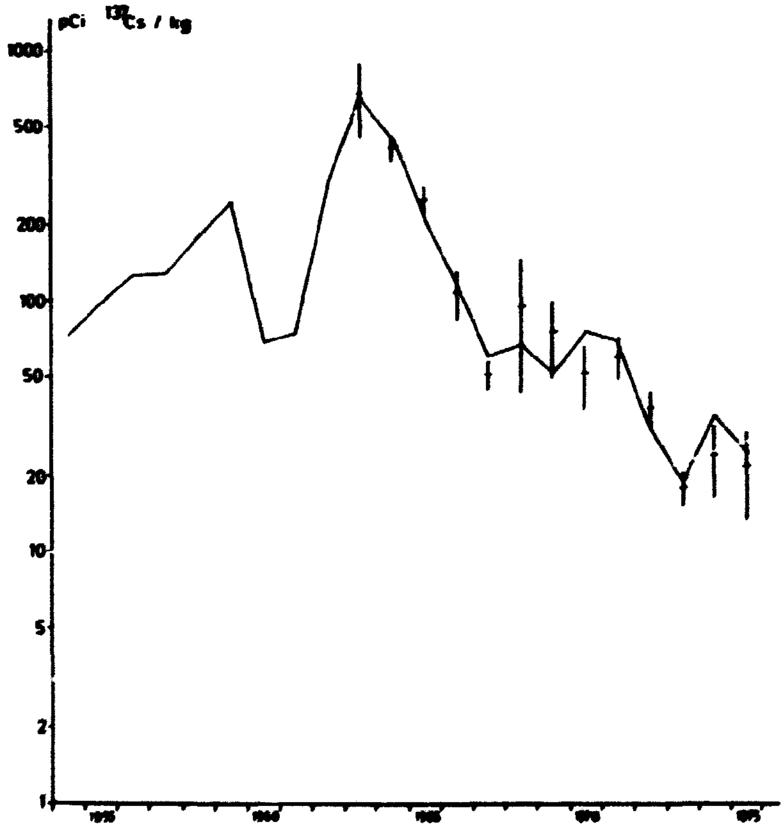

Fig. 5.8.1.2. A comparison between observed ($\pm$ 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/kg levels in beef from Denmark.

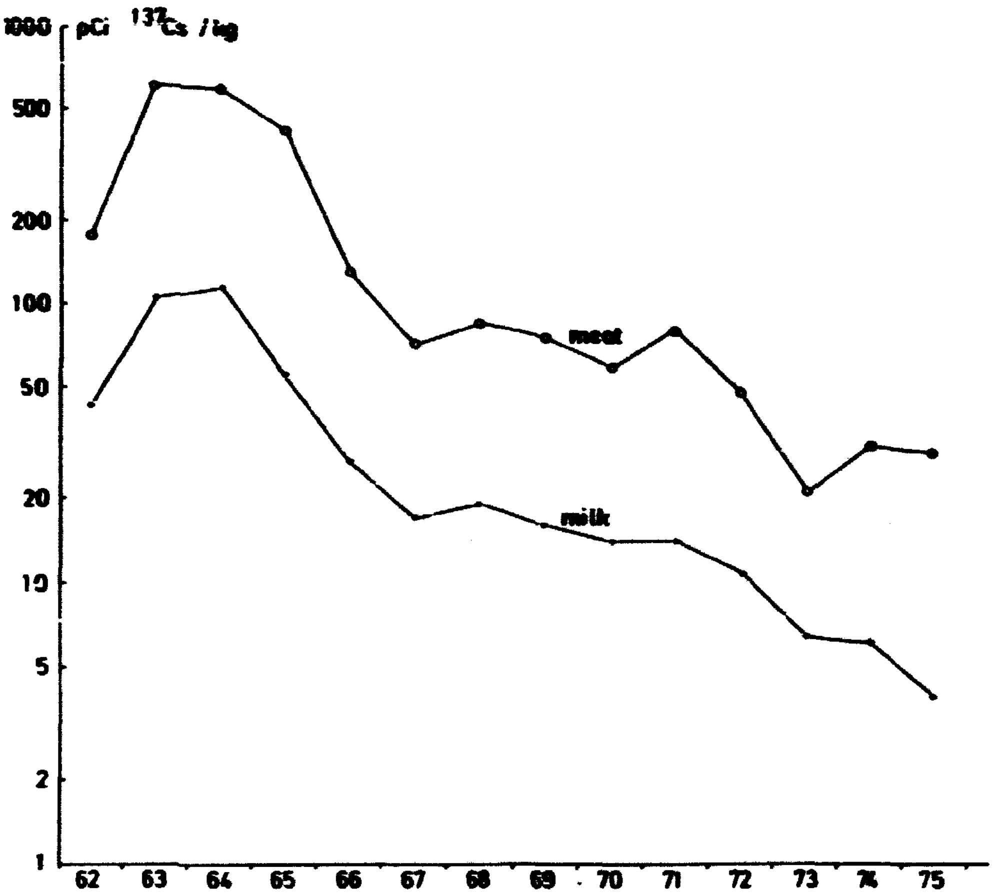

Fig. 5.8.1.3. Caesium-137 in Danish milk and meat (2/3 pork and 1/3 beef), 1962-75.

5.8.2. Strontium-90 and Caesium-137 in Fish

Fish samples were collected in inner Danish waters together with the sea-water samples (cf. 7). Tables 5.8.2.1 and 5.8.2.2 show the results. The mean levels in fish from 1975 were 69 pCi ^{137}Cs/kg (5 samples) and 0.65 pCi ^{90}Sr/kg (5 samples).

Table 5.8.2.1

Strontium-90 and Caesium-137 in fish collected in 1975

			^{90}Sr pCi/kg	^{90}Sr pCi/g Ca	^{137}Cs pCi/kg	^{137}Cs pCi/g K
Cod	54°51'N	Meat	0.53 B	0.70 B	109	29
	01°01'E	Bone	-	0.41 A	-	-
Plaice	54°44'N	Meat	0.73 A	0.85 A	42	13.0
	01°40'E	Bone	-	0.49	-	-
Herring	54°19'N	Meat	0.69 B	0.67 B	128	26
	05°29'E	Bone	-	0.25 A	-	-
Plaice	54°19'N	Meat	0.89 B	2.3 B	29	12.5
	05°27'E	Bone	-	0.38 A	-	-
Eel	Roskilde	Meat	0.41 A	1.4 A	36	12.8
	Fjord	Bone	-	0.87	-	-

Table 5.8.2.2

Caesium-137 in fish (meat + bone) collected by Dana in 1975

	Cohort	Positions		pCi/kg	M.U.
Herring	1971	54°00'N	00°15'E	105	41
"	1972	54°10'N	00°20'E	144	29
"	1974	54°10'N	00°00'E	78	33
"	1974	55°45'N	01°30'W	87	25
Mean				104	32
Sprat	1972	55°06'N	07°32'E	62	18.3
"	1974	55°12'N	05°29'E	60	23
"	1974	56°25'N	05°22'E	57	22
"	1974	56°23'N	07°09'E	55	30
Mean				58	23

5.9. Estimate of the Mean Contents of ^{90}Sr and ^{137}Cs in the Human Diet in Denmark in 1975

5.9.1. The Annual Quantities

The annual quantities are calculated by multiplication of the daily quantities by 365 (as stated by E. Hoff-Jørgensen, cf. Risø Report No. 63, table B[1]).

5.9.2. Milk and Cream

The ^{90}Sr and ^{137}Cs contents per kg milk were calculated from the annual mean values for dried milk (cf. tables 5.1.1 and 5.1.3). 1 kg ~ 1 l milk, containing approx. 1.2 g Ca and 1.66 g K. Hence the mean contents in milk were 4.9 pCi ^{90}Sr/kg and 6.1 pCi ^{137}Cs/kg.

5.9.3. Cheese

One kg of cheese contains approx. 8.5 g Ca and 1.2 g K. The ^{90}Sr and ^{137}Cs contents in cheese were calculated from these figures and from the S.U. and M.U. levels in dried milk (cf. tables 5.1.1 and 5.1.3). One kg of cheese appeared to contain 34.7 pCi ^{90}Sr and 4.4 pCi ^{137}Cs.

5.9.4. Grain Products

Tables 5.9.1 and 5.9.2 show the estimates of ^{90}Sr and ^{137}Cs respectively in grain products consumed in 1975. From these tables the activity levels in grain products were estimated at 15.0 pCi ^{90}Sr/kg and 24.6 pCi ^{137}Cs/kg.

Table 5.9.1

Estimate of the ^{90}Sr content in grain products consumed per capita in 1975

Type	Fraction from harvest 1974			Fraction from harvest 1975			Total
	kg flour	pCi/kg	pCi	kg flour	pCi/kg	pCi	pCi
Rye flour (100% extraction)	21.9	32	701	7.3	20	146	847
Wheat flour (75% extraction)	32.9	6.2	204	10.9	4.0	44	248
Grits	5.5	16.0	88	1.8	12.4	22	110
Total	60.3	16.5	993	20.0	10.6	212	1205

Table 5.9.2

Estimate of the ^{137}Cs content in grain products consumed per capita in 1975

Type	Fraction from harvest 1974			Fraction from harvest 1975			Total
	kg flour	pCi/kg	pCi	kg flour	pCi/kg	pCi	pCi
Rye flour (100% extraction)	21.9	51	1117	7.3	17	124	1241
Wheat flour (75% extraction)	32.9	15.5	510	10.9	4.6	50	560
Grits	5.5	28.3	156	1.8	12.3	22	178
Total	60.3	30	1783	20.0	9.8	196	1979

5.9.5. Potatoes

The figures in table 5.5.1 were used, i.e. 3.7 pCi ^{90}Sr/kg and 6.6 pCi ^{137}Cs/kg.

5.9.6. Vegetables

Table 5.6.5 shows the calculation of ^{90}Sr and ^{137}Cs in Danish vegetables consumed in 1975. The mean contents were 10.6 pCi ^{90}Sr/kg and 3.2 pCi ^{137}Cs/kg.

5.9.7. Fruit

The levels in imported fruit in 1975 are assumed to be equal to the mean levels found in lemons, oranges, grapes and bananas collected in Copenhagen in 1974, i.e. 6.6 pCi ^{90}Sr/kg and 2.4 pCi ^{137}Cs/kg. The mean levels in Danish fruit (apples) in 1975 were 1.7 pCi ^{90}Sr/kg and 2.1 pCi ^{137}Cs/kg (cf. 5.6). The daily mean consumption of fruit consisted of 100 g of Danish and 40 g of foreign origin. Hence the mean contents in fruit were 3.1 pCi ^{90}Sr/kg and 2.2 pCi ^{137}Cs/kg.

5.9.8. Meat

The annual mean values of ^{90}Sr and ^{137}Cs in meat were calculated from table 5.8.1: 0.8 pCi ^{90}Sr/kg and 29.3 pCi ^{137}Cs/kg. (Danish meat consists of 2/3 pork and 1/3 beef).

5.9.9. Fish

The ^{90}Sr and ^{137}Cs contents in fish are estimated from 5.8.2.1 at 0.[illegible] pCi ^{90}Sr/kg and 69 pCi ^{137}Cs/kg.

5.9.10. Eggs

The activity contents in eggs were estimated from a 1975 sample collected in Copenhagen. The levels were 0.9 pCi ^{90}Sr/kg and 2.7 pCi ^{137}Cs/kg.

5.9.11. Coffee and Tea

One third of the total consumption consists of tea and two thirds of coffee. The mean contents from 1974 were used: 24.9 pCi ^{90}Sr/kg and 36.9 pCi ^{137}Cs/kg.

5.9.12. Drinking Water

The ^{90}Sr level (population-weighted mean) found in drinking water collected in June 1973 was used as the mean level for drinking water, i.e. 0.02 pCi ^{90}Sr/l. The ^{137}Cs content in drinking water is assumed to be negligible, because it cannot be detected even in surface fresh water (cf. 4.4).

5.9.13. Discussion

Tables 5.9.3 and 5.9.4 show the estimates of ^{90}Sr and ^{137}Cs in the Danish diet in 1975. The figures should be compared with the levels calculated from the total-diet samples (cf. 5.7). The ^{90}Sr estimates obtained

Table 5.9.3

Estimate of the mean content of ^{90}Sr in the human diet in Denmark in 1975

Type of food	Annual quantity in kg	pCi ^{90}Sr per kg	Total pCi ^{90}Sr	Percentage of total pCi ^{90}Sr in food
Milk and cream	164.0	4.9	804	23.5
Cheese	9.1	34.7	316	9.2
Grain products	80.3	15.0	1204	35.2
Potatoes	73.0	3.7	270	7.9
Vegetables	43.8	10.6	464	13.6
Fruit	51.1	3.1	158	4.6
Meat	54.7	0.8	44	1.3
Eggs	10.9	0.9	9.8	0.3
Fish	10.9	0.6	6.5	0.2
Coffee and tea	5.5	24.9	137	4.0
Drinking water	548	0.02	11	0.3
Total			[illegible]	

The mean calcium intake was estimated at [illegible] g ([illegible] 200-25[illegible] g [illegible] preparate). Hence the ^{90}Sr/Ca ratio in the total diet was 5.5 S.U. in 1975.

Table 5.9.4

Estimate of the mean content of ^{137}Cs in the human diet in Denmark in 1975

Type of food	Annual quantity in kg	pCi ^{137}Cs per kg	Total pCi ^{137}Cs	Percentage of total pCi ^{137}Cs in food
Milk and cream	164.0	6.1	1000	15.8
Cheese	9.1	4.4	40	0.6
Grain products	80.3	24.6	1979	31.2
Potatoes	73.0	6.6	482	7.6
Vegetables	43.8	3.2	140	2.2
Fruit	51.1	2.2	112	1.8
Meat	54.7	29.3	1603	25.3
Eggs	10.9	2.7	29	0.5
Fish	10.9	69	752	11.9
Coffee and tea	5.5	36.9	203	3.2
Drinking water	548	0	0	0
Total			6340	

As the approximate intake of potassium was 1365 g, the pCi ^{137}Cs/g K ratio was approx. 4.6. The daily mean intake in 1975 was 17.4 pCi ^{137}Cs per capita.

by the two methods were 5.5 S.U. and 6.4 S.U. respectively, and the ^{137}Cs estimates were 17 pCi ^{137}Cs/day and 18 pCi ^{137}Cs/day. The deviations between the two estimates for ^{90}Sr are partly ascribed to the disagreement between the actual levels in bread and those calculated from grain (cf. table 5.4.3).

The relative contributions of ^{90}Sr from milk products (~33%) and from grain (35%) were nearly unchanged compared with 1974. The contribution from potatoes, other vegetables, and fruit was ~26%, i.e. also unchanged from 1974. The relative contribution of ^{137}Cs in the total diet changed as follows from 1974 to 1975: milk products were lower (22 to 16%), grain products increased from 18 to 31%, and meat was a little lower (28 to 25%).

6. STRONTIUM-90 AND CAESIUM-137 IN MAN IN 1975

6.1. Strontium-90 in Human Bone

The collection of human vertebrae from the institutes of forensic medicine in Copenhagen and Århus was continued in 1975. As in the total-food survey (cf. 5.7), the country was divided into eight zones. The samples were divided into five age groups: new-born (< 1 month), infants (1 month - 4 years), children and teenagers (5 - 19 years), adults (≤ 29 years) and adults (> 29 years).

Tables 6.1.1 - 6.1.5 show the results for the five groups.

The levels were generally a little higher in 1975 than in 1974. The highest mean level in vertebrae was found in infants, but the levels in the different age groups were not much different.

Table 6.1.1

Strontium-90 in bone from new-born children (< 1 month old) in 1975

Zone	Age in days	Month of death	Sex	pCi ^{90}Sr/g Ca
II	8	6	F	1.31 A

Table 6.1.2

Strontium-90 in bone from infants (≤ 4 years old) in 1975

Zone	Age in years and months	Month of death	Sex	pCi ^{90}Sr/g Ca
I	1 m	5	M	2.85 A
I	2 m	6	M	2.27 B
VI	1 y 7 m	3	M	2.63
VI	1 y 8 m	3	M	2.22
VI	2 m	10	M	2.01 A
VI	2 y 9 m	4	M	1.32 A
VI	4 m	12	F	1.53
VI	~ 5 m	~10	F	1.96*
VI	~ 3 m	~10	F	1.36**
VI	10 m	3	F	1.89 A

*) 3 samples combined in one analysis

**) 2 samples combined in one analysis

Table 6.1.3

Strontium-90 in bone from children and teen-agers (≤ 19 years) in 1975

Zone	Age in years	Month of death	Sex	pCi $^{90}Sr/g$ Ca
I	17	6	M	1.44
I	11	10	M	1.40
II	18	6	M	1.66
VI	8	5	F	1.03 B
VI	16	9	F	1.48
VI	5	5	F	2.76 A
VI	6	3	F	1.84
VI	18	4	F	1.09
VI	14	12	F	0.84 A
VI	9	12	F	1.69
VI	14	2	F	1.20 A
VI	14	2	F	1.61 A
VI	11	2	F	1.17 B
VI	16	3	M	1.85
VI	19	10	M	1.73
VI	15	12	M	1.41
VI	18	12	M	1.35
VI	9	12	M	1.43
VI	8	10	M	1.39 B
VI	5	5	M	3.00 A
VI	10	2	M	1.65 B
VI	18	5	M	0.89
VI	11	6	M	1.99
VI	14	12	M	0.96 B
VI	13	12	M	0.97 A
VI	14	12	M	1.19 A
VI	19	2	M	1.24 A
VI	16	2	M	0.98
VI	17	11	M	2.09
VI	11	11	M	1.19
VI	19	11	M	1.42 A
VI	17	11	M	1.01

Table 6.1.4

Strontium-90 in vertebrae from adults (≤ 29 years) in 1975

Zone	Age in years	Month of death	Sex	pCi $^{90}Sr/g$ Ca
I	27	5	M	1.24
I	22	11	M	1.19
II	26	6	F	1.33
II	25	6	F	1.87
II	27	6	F	1.14
II	26	5	F	1.24
II	25	1	F	1.12
II	23	10	M	1.79
II	20	3	M	1.54
VI	28	12	F	0.84 A
VI	23	4	F	1.65
VI	21	5	F	0.98
VI	20	3	M	1.87
VI	21	3	M	1.81
VI	26	5	M	2.32
VI	26	3	M	1.48
VI	24	10	M	1.60
VI	21	10	M	1.28 A
VI	25	12	M	1.52
VI	21	4	M	1.04
VI	24	4	M	1.39
VI	22	2	M	1.49
VI	20	5	M	1.05
VI	23	5	M	1.06
VI	22	6	M	1.47
VI	25	6	M	1.60
VI	28	12	M	1.65
VI	20	12	M	1.67
VI	24	1	M	0.[illegible]
VI	26	10	M	1.15
VI	22	10	M	1.36
VI	22	10	M	1.16
VI	23	10	M	1.29

Table 6.1.5

Strontium-90 in vertebrae from adults (> 29 years old) in 1975

Zone	Age in years	Month of death	Sex	pCi ^{90}Sr/g Ca
I	54	5	F	1.87
I	48	1	M	1.02
I	48	5	M	1.46
I	46	11	M	1.56
I	59	12	M	3.87
I	51	1	M	1.63
II	69	3	F	1.15
II	64	3	F	1.11
II	56	6	F	1.06
II	43	6	F	1.40
II	52	5	F	0.94 A
II	77	6	F	1.25
II	39	5	F	1.11
II	46	1	F	1.15
II	71	2	M	1.73
II	66	5	M	1.58
II	51	1	M	1.00 A
II	33	6	M	1.20
II	73	12	M	1.26
II	74	11	M	1.09
II	52	2	M	1.74
II	62	2	M	1.82
II	69	1	M	1.78
II	38	1	M	1.49
II	34	1	M	1.97
III	63	4	F	2.36 A
III	74	1	F	2.06 B
III	54	1	F	0.98 B
III	63	2	M	1.52
III	57	2	M	2.82
III	46	2	M	1.91
III	41	10	M	2.36
III	52	4	M	0.97 A
III	72	5	M	1.49
III	59	3	M	1.75
III	60	11	M	1.73
VI	31	10	F	1.24
VI	34	10	F	1.49
VI	31	4	F	1.12
VI	66	11	F	1.35
VI	35	10	F	2.52
VI	38	11	F	1.24
VI	69	4	M	1.33 A
VI	35	1	M	1.14
VI	37	6	M	1.[illegible]4
VI	34	12	M	1.51 A
VI	38	11	M	1.11
VI	75	11	M	2.26
VI	66	11	M	1.43
VI	44	1	M	1.06
VI	38	10	M	1.39 A
VI	35	10	M	1.05

Table 6.1.6

Strontium-90 (pCi/g Ca) in human vertebrae collected in Denmark in 1975

Age group	Number of samples	Number of analysis	Min.	Max.	Median	Mean of analysis	Sample number weighted mean
New-born (< 1 month)	1	1	1.31	1.31	1.31	1.31	1.31
Infants (≤ 4 years)	13	10	1.32	2.85	1.98	2.00	1.95
Children (≤ 19 years)	32	32	0.84	3.00	1.41	1.47	1.47
Adults (≤ 29 years)	33	33	0.84	2.32	1.36	1.40	1.40
Adults (≥ 30 years)	52	52	0.94	3.87	1.41	1.53	1.53

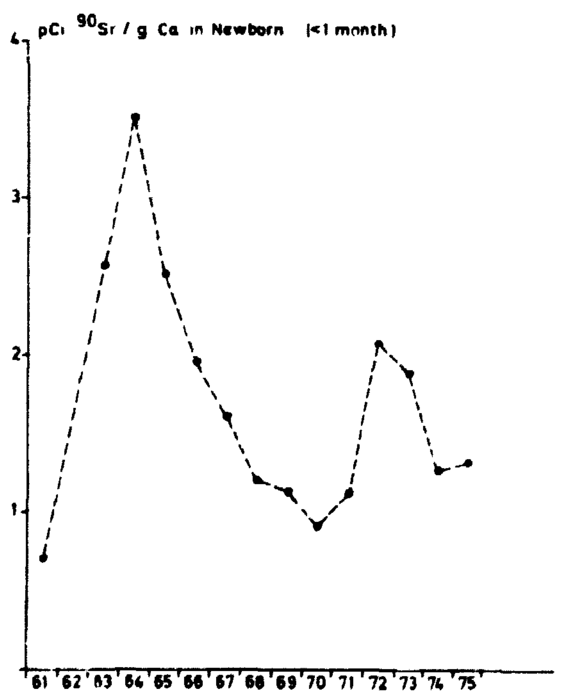

Fig. 6.1.1. Strontium-90 in bone from newborn 1961-75.

Fig. 6.1.2. Strontium-90 in bone from infants 1962-75.

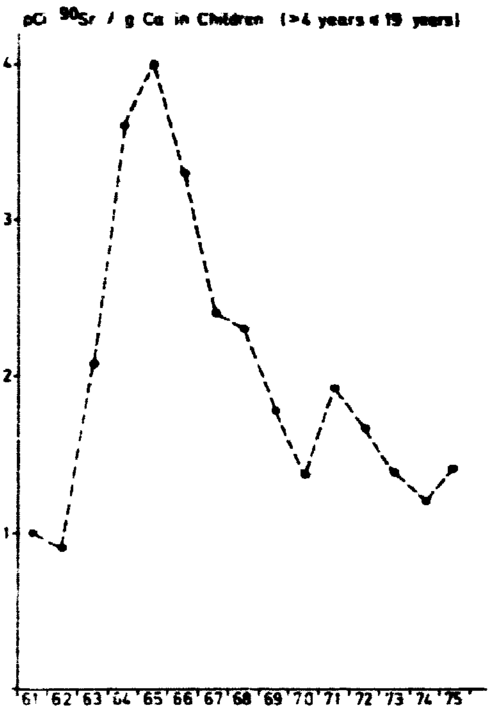

Fig. 6.1.3. Strontium-90 in bone from children 1961-75.

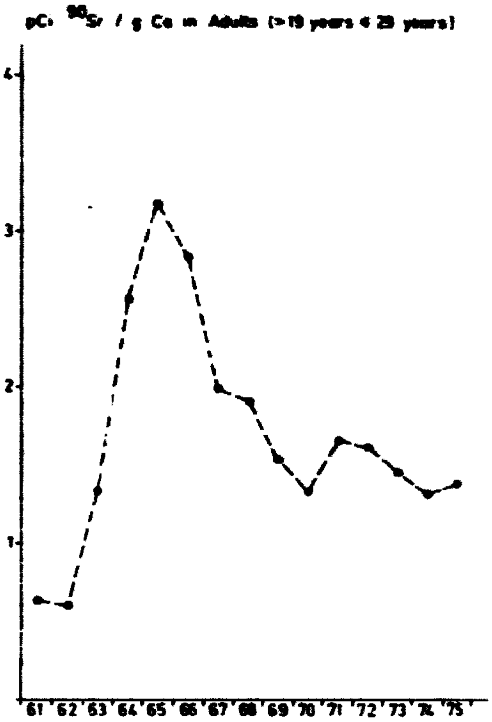

Fig. 6.1.4. Strontium-90 in vertebrae from adults ≤ 29 y, 1961-75.

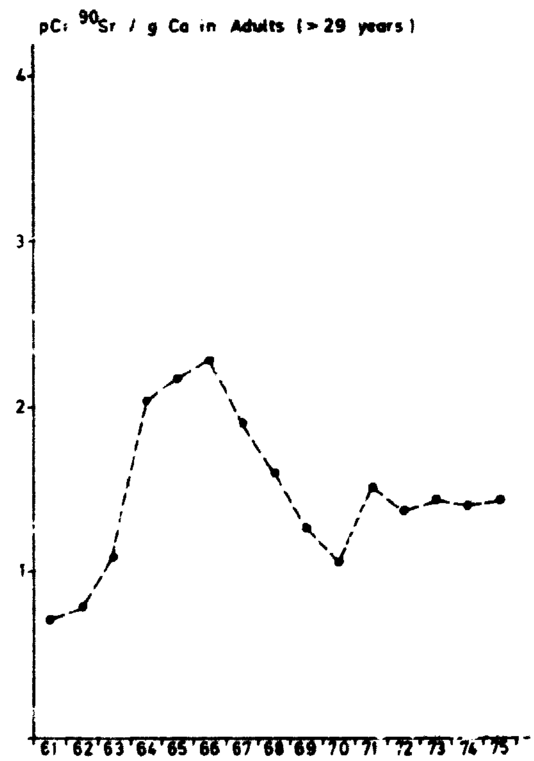

Fig. 6.1.5. Strontium-90 in vertebrae from adults > 29 y 1961-75.

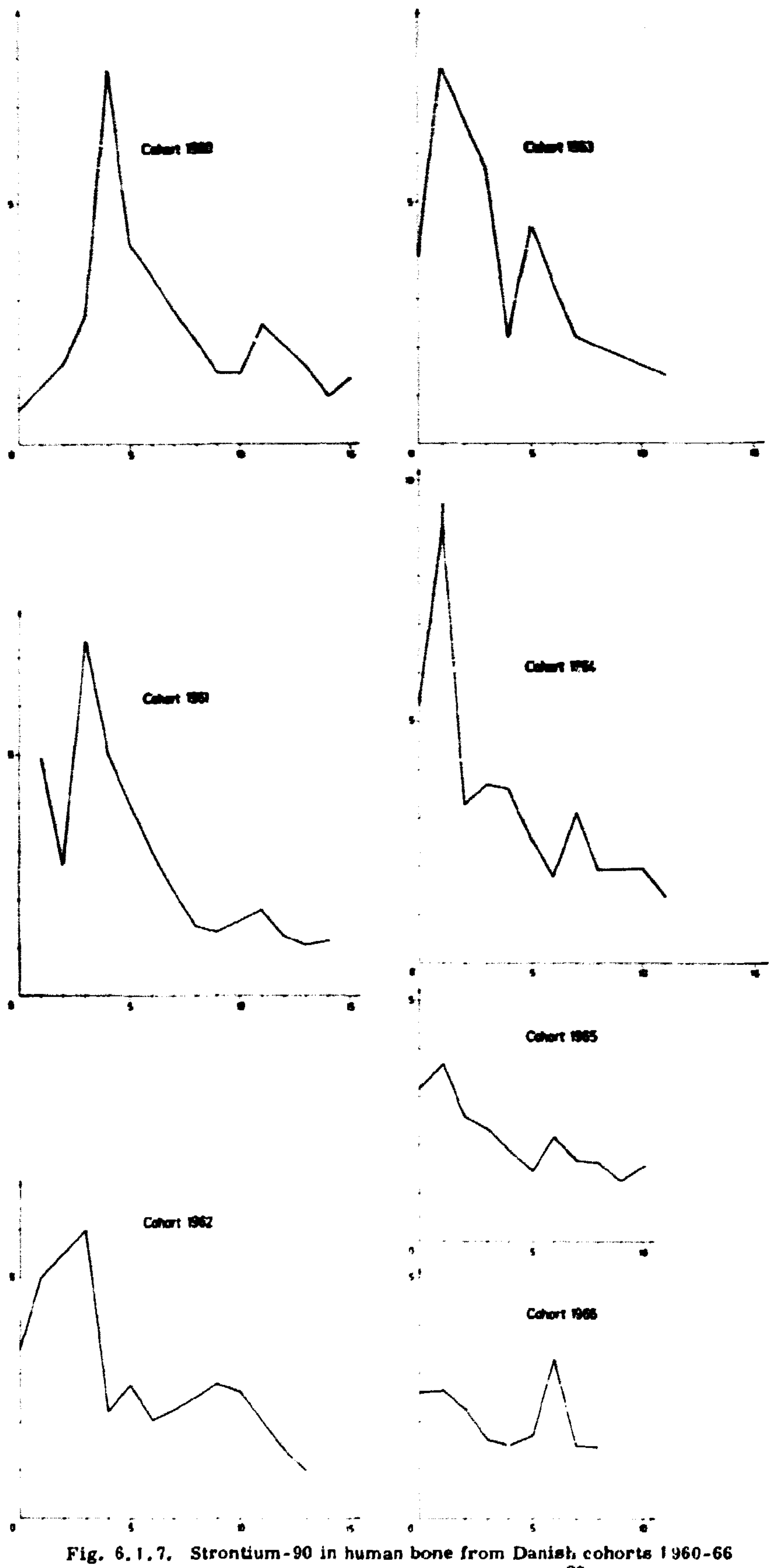

Fig. 6.1.7. Strontium-90 in human bone from Danish cohorts 1960-66 (abscissa: age in years. Ordinate: bone level in pCi ^{90}Sr/g Ca).

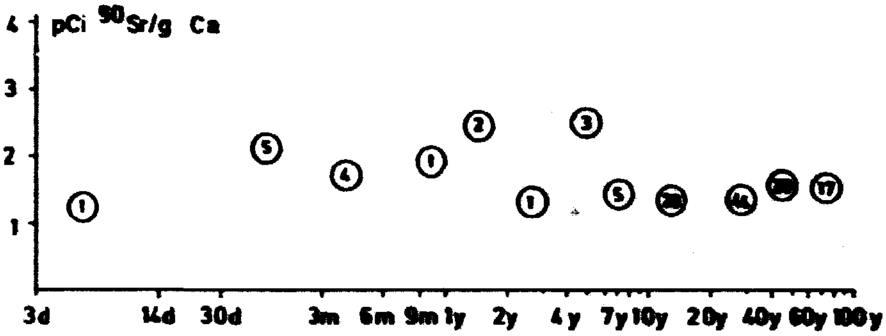

Fig. 6.1.6. Strontium-90 in human vertebrae in 1975 (the figures in the circles indicate the number of samples).

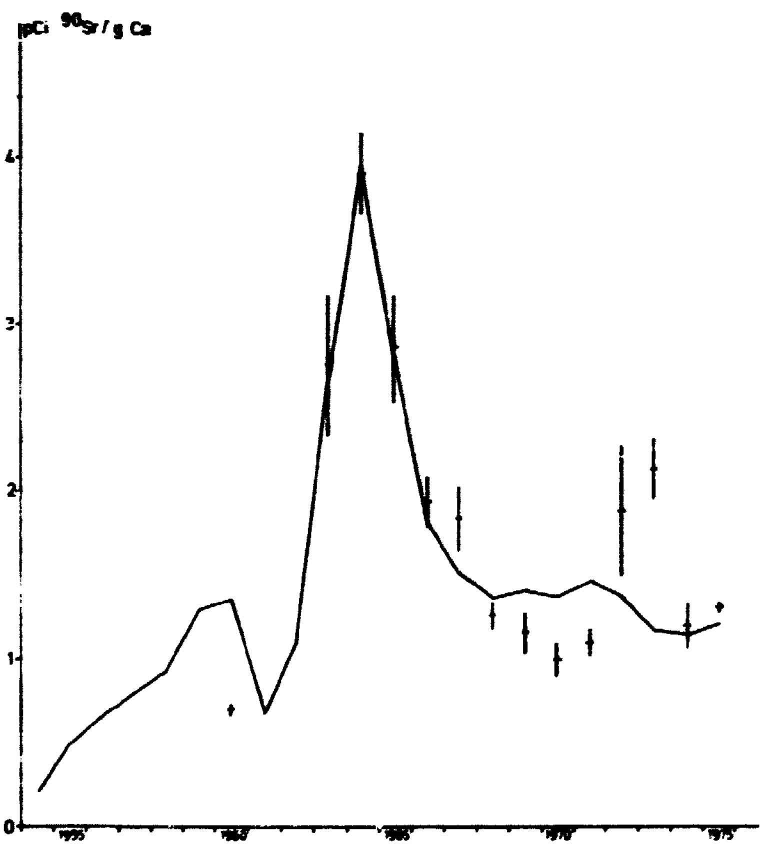

Fig. 6.1.8. Predicted S. U. levels in newborn bone from Denmark (curve, cf. appendix C) compaired with the measured mean levels ($\pm$ 1 S. E.).

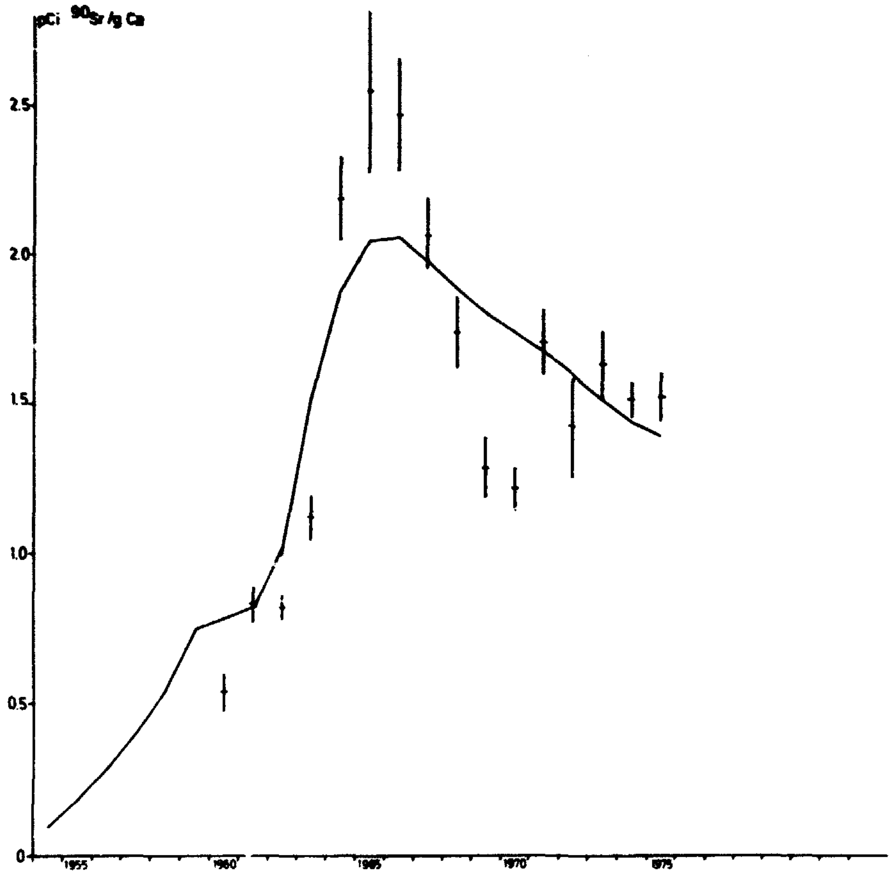

Fig. 6.1.9. Predicted S.U. levels in adult vertebrae (> 29 year) bone from Denmark (curve, cf. appendix C) compaired with the measured mean levels ($\pm$ 1 S.E.).

6.2. Caesium-137 in the Human Body

In July 1963 whole-body measurements were initiated at Risø in the low-level counting room in the Health Physics Department (cf. 2.3 in Risø Report No. 85[1]). A control group from the Health Physics Department was selected and has since then been measured three times a year, but in 1975 only two times. Table 6.2 shows the results.

The annual mean value of the control group was 11.3 pCi ^{137}Cs/g K. As earlier, we shall consider this figure representative of the mean of the Danish population in 1975. The total-body content of ^{137}Cs in 1975 for a standard man containing 140 g of potassium equals $140 \cdot 11.3 \cdot 10^{-3}$ nCi = 1.6 nCi ^{137}Cs, i.e. nearly unchanged from 1973 and 1974.

Figure 6.2 shows the mean M.U. values (with one S.E.) for men and women measured in 1963-1975.

The maximum was reached in August 1964. The figure also shows that the mean level in the male group was approx. 1.3 - 1.5 times as high as that in the female group.

Table 6.2

Whole-body measurements of caesium-137 and potassium in 1975

No.	Sex	Counting date	Age	Height in cm	Weight in kg	M.U. in body	pCi ^{137}Cs/kg	g K/kg body weight
1	F	Sept.	25	160	57	7.2	12.7	1.8
2	F	-	27	165	52	20.0	39.9	2.0
4	F	-	51	161	58	4.4 B	7.2 B	1.6
7	F	-	47	171	63	9.2 A	17.2 A	1.9
8	M	-	43	193	79	6.9 A	13.7 A	2.0
15	F	-	39	165	53	33.8	57.6	1.7
18	M	-	36	178	78	7.5 A	15.3 A	2.0
19	M	-	33	174	72	7.5 A	16.4 A	2.2
20	M	-	43	172	69	21.2	43.8	2.1
22	M	-	52	183	73	6.2 A	16.2 A	2.6
26	F	-	36	160	54	5.2 B	8.5 B	1.6
30	M	-	29	168	60	8.2	18.5	2.3
31	M	-	33	182	75	34.1	78.4	2.3
35	M	-	34	181	71	12.2	26.9	2.2
39	F	-	26	172	60	3.4 A	5.2 A	1.5
43	M	-	58	167	69	3.2 B	6.8 B	2.1
44	M	-	25	170	54	3.1	5.5	1.8
48	F	-	36	162	50	3.9 B	6.4 B	1.7
50	M	-	27	169	69	9.1 A	20.9 A	2.3
53	F	-	49	154	101	B.D.L.	B.D.L.	1.5
55	F	-	33	165	89	4.3 A	7.9 A	1.8
56	F	-	19	169	50	2.6 B	4.4 B	1.7
57	M	-	26	187	76	5.1 B	10.8 B	2.1
58	F	-	23	169	53	2.5 B	4.2 B	1.7
4	F	Dec.	51	161	58	B.D.L.	B.D.L.	1.6
7	F	-	47	171	63	14.2 A	22.8 A	1.7
8	M	-	43	193	79	15.9	31.7	2.0
15	F	-	39	165	53	7.5 B	12.0 B	1.6
18	M	-	36	178	78	B.D.L.	B.D.L.	1.9
19	M	-	33	174	72	B.D.L.	B.D.L.	2.0
20	M	-	42	172	69	10.1	20.1	2.0
22	M	-	52	183	73	8.5 B	17.0 B	2.2
23	M	-	45	192	85	22.3	44.5	2.0
24	M	-	44	170	75	4.5 B	9.0 B	2.0
25	F	-	33	167	55	11.0 A	16.4 A	1.5
26	F	-	36	160	54	11.3 A	19.2 A	1.7
31	M	-	33	182	75	32.2	67.7	2.1
32	F	-	46	157	60	7.6	12.1	1.6
33	M	-	44	184	62	9.0 A	18.9 A	2.1
35	M	-	34	181	71	14.4 A	25.9 A	1.8
39	F	-	26	172	60	2.3	3.4	1.8
43	M	-	63	167	69	13.2 A	23.8 A	1.8
44	F	-	25	170	54	26.8	48.2	1.8
48	F	-	36	162	50	21.9	41.6	1.9
50	M	-	27	169	69	10.5 A	24.1 A	2.3
51	M	-	43	175	89	13.6 A	24.4 A	1.8
52	F	-	38	173	57	47.0	93.9	2.0
53	F	-	49	154	101	26.1	36.6	1.4
54	F	-	35	163	62	7.4	11.1	1.5
55	F	-	33	165	89	4.8 B	8.1 B	1.7
58	F	-	23	169	53	14.8 A	23.9 A	1.7
59	M	-	28	190	83	10.1 A	20.2 A	2.0

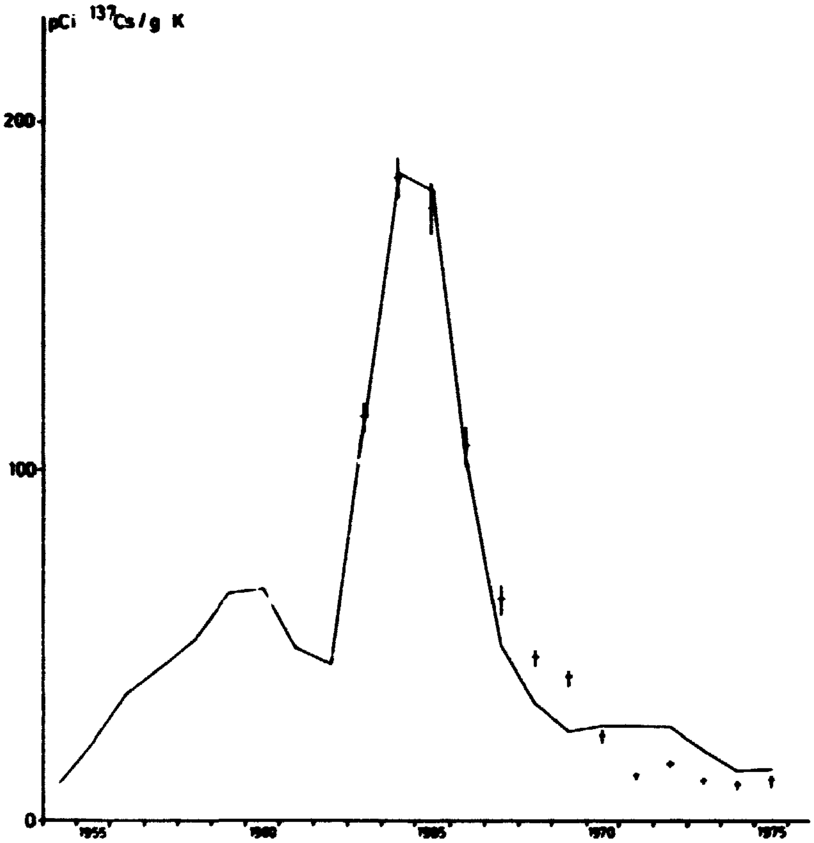

Fig. 6.2. A comparison between observed (± 1 S.E.) and calculated (curve, cf. appendix C) pCi ^{137}Cs/g K levels in whole-body from the Islands.

7. STRONTIUM-90 AND CAESIUM-137 IN SEA WATER IN 1975

As in previous years, seawater samples were collected by M/S Fyrholm in the summer and late autumn from inner Danish Waters (cf. table 7.1 and figs. 7.1 and 7.2). Furthermore, seawater samples were collected at Barsebäck in the Sound (table 7.2), and at Ringhals in the Cattegat (table 7.3). The DANA took samples in the North Sea and the Skagerak in February and in June (table 7.4).

In Risø Report No. 305[1] it was suggested that the increasing ^{90}Sr and ^{137}Cs levels observed in 1973 in inner Danish waters were due to contamination from inflow of water from the North Sea contaminated with ^{137}Cs and ^{90}Sr from nuclear plants in the UK and France.

Table 7.1

Strontium-90 and Caesium-137 in sea water collected around Zealand in May and November 1975

	Position		May				November			
	N	E	depth in m	^{90}Sr pCi/l	Salinity o/oo	^{137}Cs pCi/l	depth in m	^{90}Sr pCi/l	Salinity o/oo	^{137}Cs pCi/l
Kullen	56°15'	12°25'	0	0.68	12.6	0.96	0		22.6	0.98
"			21		34.0	0.49	21	0.54	33.6	0.90
Besselø	56°10'	11°47'	0		17.9	0.89	0	0.71	20.4	0.62
"			24	0.54	33.8	0.76	22		32.0	1.21
Kattegat SW	56°07'	11°10'	0	0.65	15.7	0.74	0		21.1	0.57
"			35		33.8	0.76	42	0.65	29.7	1.13
Asnæs rev	55°38'	10°47'	0		16.1	0.88	0	0.78	16.7	0.73
" "			47	0.50	32.7	0.85	45		28.2	0.97
Halskov rev	55°20'	11°02'	0	0.75	16.1	1.07	0		17.6	0.69
" "			45		31.0	0.91	45	0.68	25.5	0.97
Langeland bælt	54°52'	10°50'	0		16.7	0.86	0		17.3	0.71
" "			42	0.60	28.4	1.12	47		23.5	0.92
Femern bælt	54°36'	11°05'	0	0.69	12.6	0.77	0		17.8	0.73
" "			27		26.5	1.15	26	0.74	17.3	0.90
Gedser rev	54°28'	12°13'	0		10.0	0.74	0	0.61	13.3	1.07
" "			26	0.72	14.9	1.02	25		14.2	0.75
Møen	54°57'	12°41'	0	0.60	8.4	0.70	0		9.0	0.71
"			20		11.0	0.78	25	0.63	14.6	0.90
The Sound - south	55°25'	12°39'	0	0.76	8.1	0.68	0		8.8	0.59
" " "			12		8.2	0.82	13		9.5	0.62
The Sound - north A	55°48'	12°44'	0	0.72	9.3	0.40	0		15.2	0.52
" " "			19		31.8	1.08	19	0.43	31.7	1.12
The Sound - north B	55°59'	12°42'	0		14.2	0.66	0		21.9	0.71
" " "			26	0.41	33.1	0.90	26		32.1	1.09
Mean			Surface	0.69	13.2	0.78	Surface	0.70	16.8	0.72
SD				0.06	3.5	0.17		0.09	4.6	0.16
SE				0.02	1.0	0.05		0.05	1.3	0.05
Mean			Bottom	0.55	26.6	0.89	Bottom	0.61	24.3	0.96
SD				0.12	9.6	0.19		0.11	8.4	0.17
SE				0.05	2.8	0.05		0.05	2.4	0.05

In accordance with this assumption the ^{90}Sr concentration has especially increased in sea water of high salinity as shown in the following regression equations:

$$\text{pCi } ^{90}\text{Sr l}^{-1} = 0.94 - 0.018 \text{ o/oo} \quad (1967\text{-}71)$$
$$\text{pCi } ^{90}\text{Sr l}^{-1} = 0.97 - 0.020 \text{ o/oo} \quad (1972)$$
$$\text{pCi } ^{90}\text{Sr l}^{-1} = 0.95 - 0.014 \text{ o/oo} \quad (1973)$$
$$\text{pCi } ^{90}\text{Sr l}^{-1} = 0.93 - 0.010 \text{ o/oo} \quad (1974)$$
$$\text{pCi } ^{90}\text{Sr l}^{-1} = 0.79 - 0.006 \text{ o/oo} \quad (1975)$$

Table 7.2

Strontium-90 and Caesium-137 in sea water collected in the Sound (Barsebäck) in 1975

Position		June				December			
N	E	depth in m	^{90}Sr pCi/l	^{137}Cs pCi/l	Salinity o/oo	depth in m	^{90}Sr pCi/l	^{137}Cs pCi/l	Salinity o/oo
55°42'08"	12°54'	0		0.69	8.6	0		0.71	16.0
-"-	-"-	14	0.64	0.99	19.4	13		1.00	31.7
55°47'05"	12°51'07"	0		0.83	9.1	0	0.58	0.71	17.8
-"-	-"-	15	0.56	1.19	20.2	15		0.97	32.0
Mean		Surface		0.76	8.8	Surface	0.58	0.71	16.9
SD				0.10	0.4			0.00	1.3
SE				0.07	0.2			0.00	0.9
Mean		Bottom	0.60	1.09	19.8	Bottom		0.99	31.8
SD			0.06	0.14	0.6			0.02	0.2
SE			0.04	0.10	0.4			0.01	0.2

Table 7.3

Strontium-90 and Caesium-137 in sea water collected at Ringhals in July 1975

Position		Depth in m	^{90}Sr pCi/l	^{137}Cs pCi/l	Salinity o/oo
N	E				
57°16'05"	12°06'	0	0.50	0.64	17.4
- " -	- " -	15	0.87	0.93	21.0
57°13'03"	12°03'04"	0	1.11	0.85	17.9
- " -	- " -	22	0.80	0.89	33.3
57°14'	11°53'06"	0	0.91	0.79	18.3
- " -	- " -	77	0.76	1.04	33.8
Mean		Surface	0.84	0.76	17.9
S.D.			0.31	0.11	0.5
S.E.			0.18	0.06	0.3
Mean		Bottom	0.81	0.95	29.4
S.D.			0.06	0.08	7.3
S.E.			0.03	0.04	4.2

Table 7.4

Strontium-90 and Caesium-137 in sea water collected in the North Sea and Skagerak in 1975

Position	Date	pCi ^{90}Sr/l	pCi ^{137}Cs/l	Salinity o/oo
56°38'N 07°19'E	27/2		1.68	34.2
54°19'N 05°27'E	11/2	1.34	1.62	34.5
57°30'N 08°00'E	27/2	0.87	1.00	28.0
56°00'N 00°23'W	20/2		1.49	27.7
53°56'N 03°51'E	13/2	1.47	1.56	34.5
58°12'N 09°20'E	28/2	0.93	1.07	26.8
- " - - " -	1/3	0.80	1.00	30.9
- " - - " - *	28/2	0.37	0.68	34.7
- " - - " - *	28/2		0.52	-
- " - - " - **	28/2	0.34	0.79	35.0
- " - - " - **	28/2		0.52	34.7
55°19'N 07°40'E	9/2		1.43	32.3
54°44'N 01°40'E	21/2		2.03	34.5
55°17'N 04°45'E	16/2		1.56	34.2
57°03'N 01°39'W	17/2	1.43	2.54	34.5
57°15'N 04°30'E	20/6	0.48	0.97	32.1
60°15'N 00°30'E	23/6	0.24	0.46	32.7
59°55'N 02°10'W	20/6	0.21	0.72	34.7
58°15'N 02°35'E	21/6	0.42	1.04	32.8
59°15'N 01°30'E	22/6	0.39	0.79	33.0
58°35'N 03°50'W	June	0.18	0.57	34.6
60°45'N 00°10'W	June	lost	2.40	34.5
Mean		0.67	1.20	32.9
S.D.		0.46	0.60	2.5
S.E.		0.12	0.12	0.5

*640 m depth Risø collector **640 m depth U.S.A. collector

(The regression analysis showed significant or probably significant regression in all cases except in 1973 and in 1975).

In analogy with ^{90}Sr, the following regression equations were found for ^{137}Cs in inner Danish waters:

$$\text{pCi } ^{137}\text{Cs l}^{-1} = 0.80 - 0.0043 \text{ o/oo} \quad (1972)$$
$$\text{pCi } ^{137}\text{Cs l}^{-1} = 0.60 + 0.012 \text{ o/oo} \quad (1973)$$
$$\text{pCi } ^{137}\text{Cs l}^{-1} = 0.54 + 0.018 \text{ o/oo} \quad (1974)$$
$$\text{pCi } ^{137}\text{Cs l}^{-1} = 0.64 + 0.010 \text{ o/oo} \quad (1975)$$

(The regression analysis showed a highly significant regression in 1974, probably significant in 1973 and 1975, and insignificant in 1972).

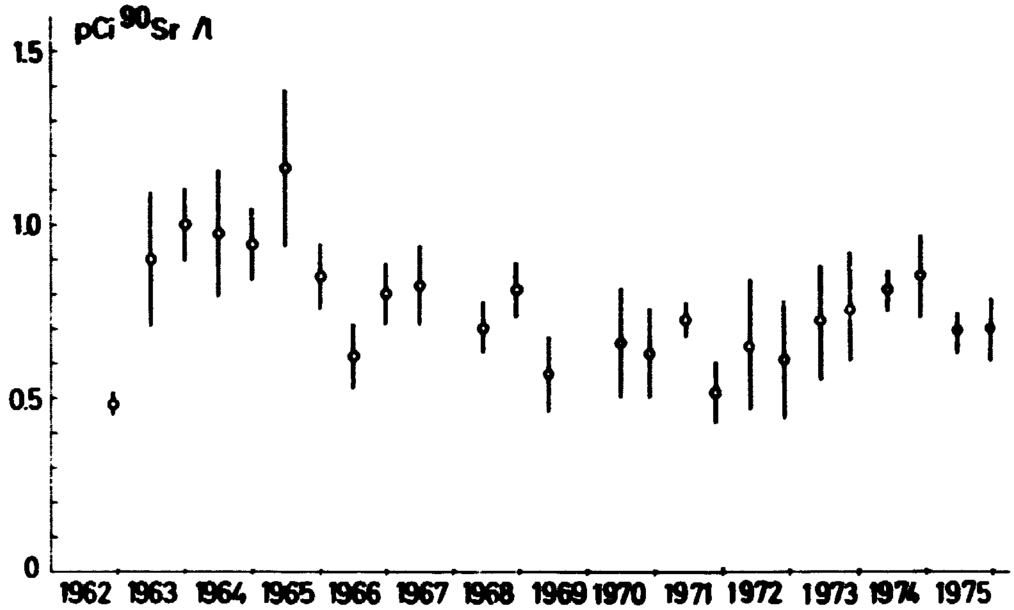

Fig. 7.1. Strontium-90 in surface sea-water from inner Danish waters, 1962-75 (1 S.D. indicated) (from table 7.1).

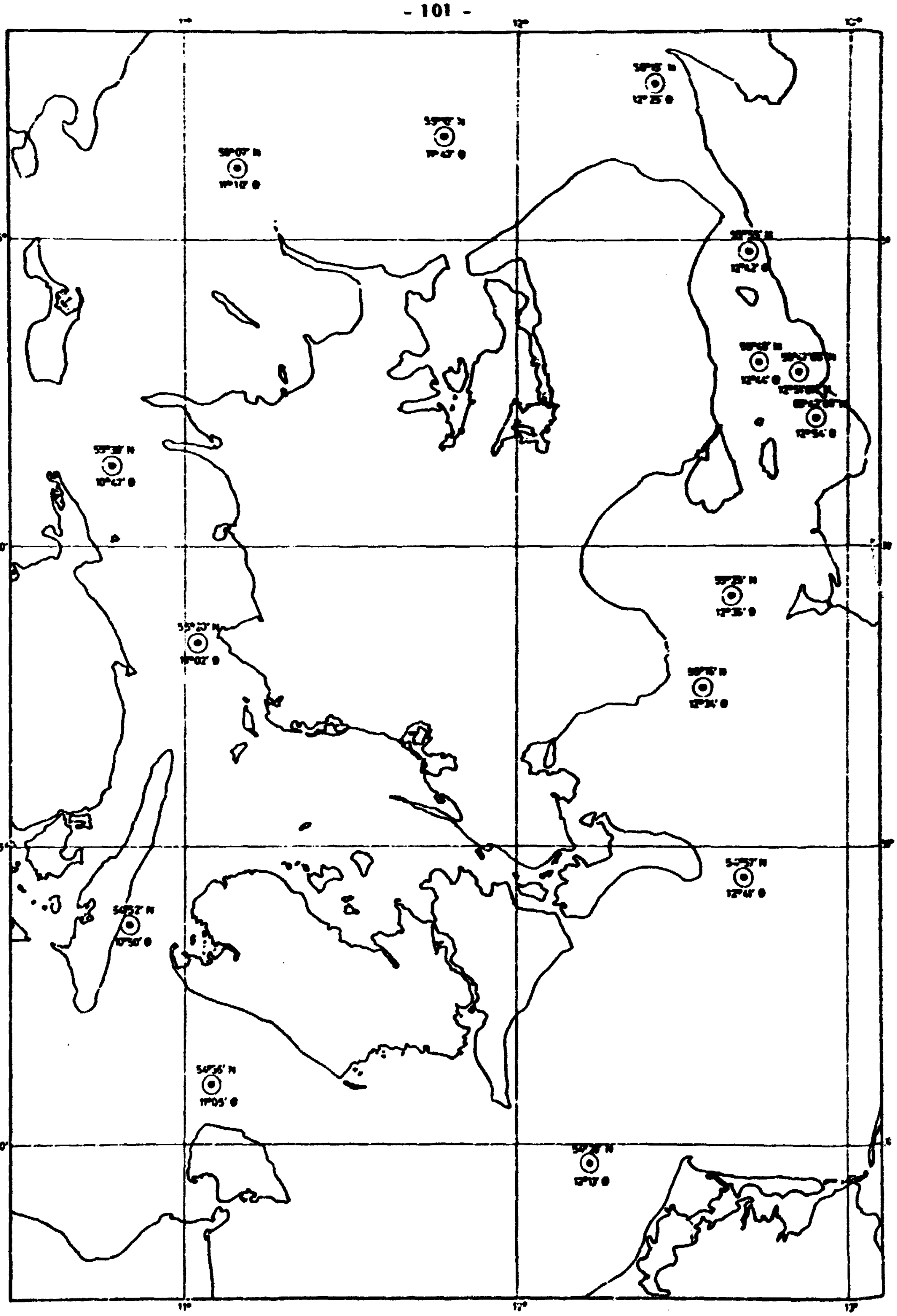

Fig. 7.2. Sea-water locations around Zealand.

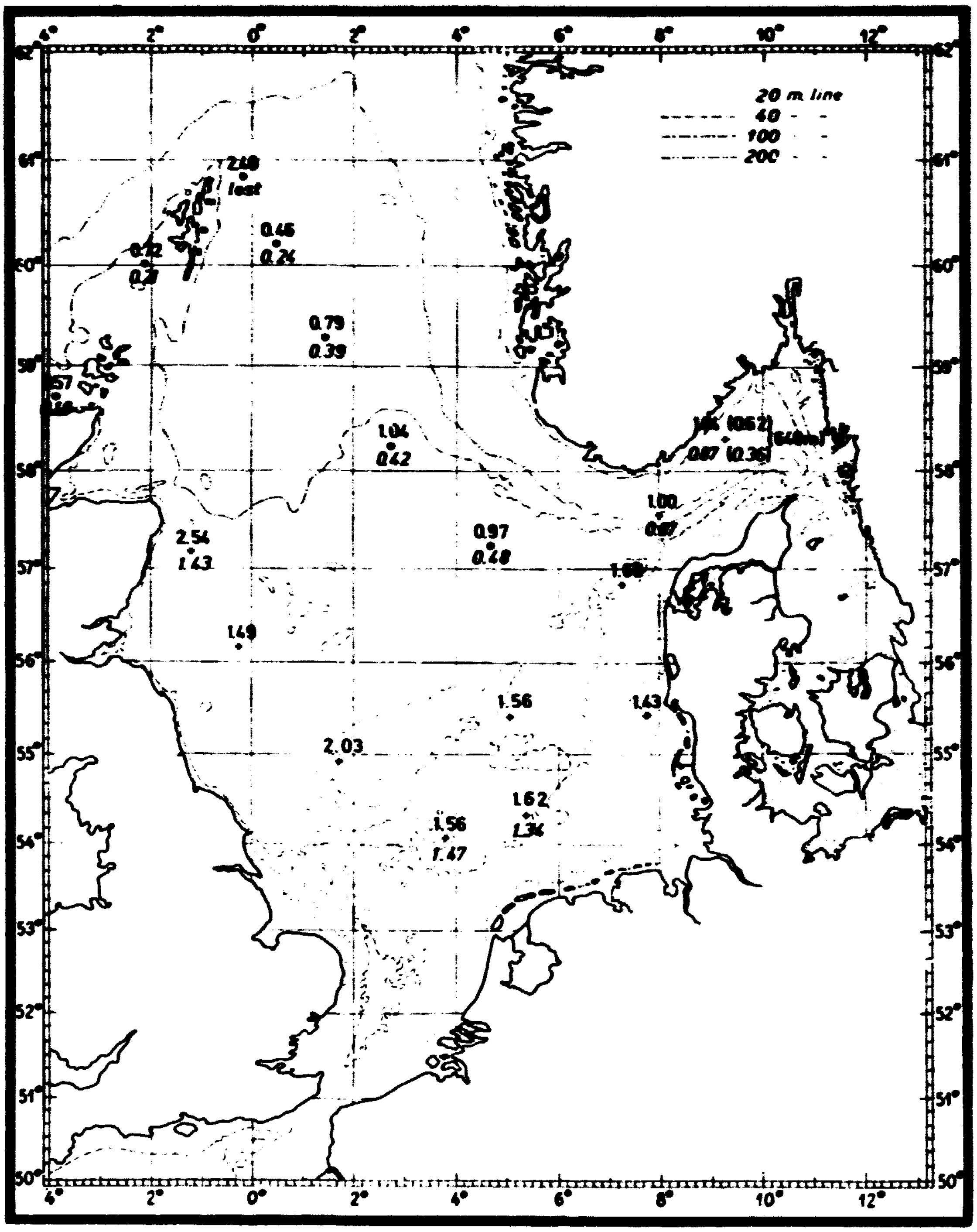

Fig. 7.5. Concentrations (pCi/l) of ^{137}Cs and ^{90}Sr (italics) in surface sea-water collected in February (+) and June (·) 1975.

8. SPECIAL SURVEYS

8.1. Meteorological Mast Experiment

No samples were collected in 1975.

8.2. Fission Product Ratios in Air Samples Collected at Different Heights in the Meteorological Mast

No samples were collected in 1975.

8.3. Human Milk

No human milk samples were collected in 1975.

8.4. Country-wide Measurement of the γ-Background in 1975

8.4.1. State Experimental Farms

As in previous years[1], the γ-background was measured at the State experimental farms (cf. fig. 4.1.1). Table 8.4.1.1 shows the results, and table 8.4.1.2 gives the analysis of variance. The variations between locations was highly significant (P > 99.95%). As in previous years, it was evidently not the fall-out that determined the variation between locations. The mean level in 1975 was higher than the 1974 level which was unusual lower (cf. Risø Report No. 323[1]).

Table 8.4.1.1

γ-background at the state experimental farms in 1975 (μR/h)

	Mar.	May	Oct.	Mean
Tylstrup	5.4	5.3	5.4	5.4
Studsgård	4.2	3.9	4.4	4.2
Ødum	6.5	6.4	6.9	6.6
Askov	5.8	5.6	5.9	5.8
St. Jyndevad	3.4	3.9	4.1	3.8
Blangstedgård	6.8	6.6	6.7	6.7
Tystofte	7.3	7.4	7.5	7.4
Virumgård	7.2	6.7	6.8	6.9
Ledreborg	7.2	7.2	7.3	7.2
Abed	6.4	6.5	6.7	6.5
Åkirkeby	(8.6)	8.6	(8.8)	(8.7)
Mean	(6.2)	6.2	(6.4)	(6.3)

Table 8.4.1.2

Analysis of variance of the γ-background
at the state experimental farms in 1975
(from table 8.4.1.1)

Variation	SSD	f	s^2	v^2	P
Between locations	274.060	10	27.406	159.114	>99.95%
Between months	1.782	2	0.891	5.174	>97.5%
Loc. x months	3.100	18	0.172	0.787	-
Remainder	30.406	139	0.219		

Fig. 8.4 shows the γ-background since 1962 in four groups of sampling stations. The fact that stations with a low fall-out rate and a high clay content in the soil (Abed, Blangstedgård, and Tystofte) show higher γ-levels than stations with a high fall-out rate and a low clay content (but a high sand content) (Studsgård, St. Jyndevad, and Askov) was discussed in Risø Report No. 154[1)].

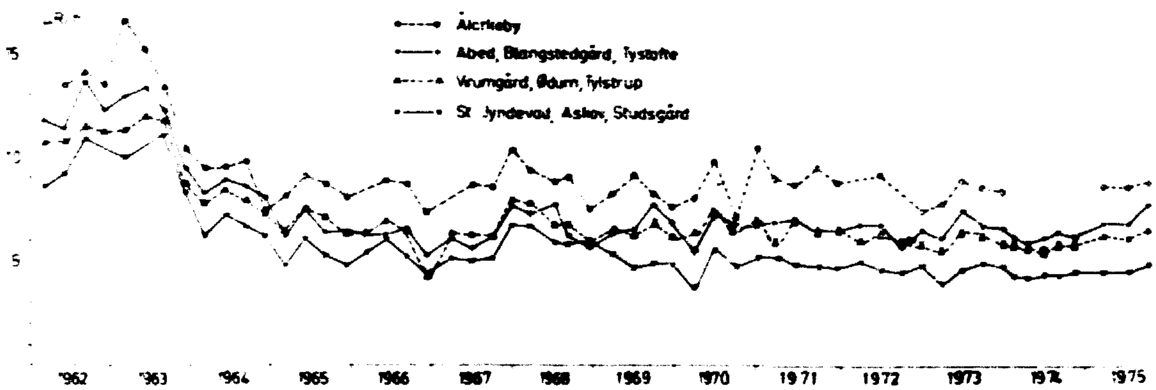

Fig. 8.4. The γ-background at the State experimental farms, 1962-75.

8.4.2. The Risø Environment

Gamma background measurements were performed in the five zones round Risø. The measurements were carried out at the locations where grass is collected (cf. figs. 3.1.2.1 and 3.1.2.2 (the coloured map)).

Tables 8.4.2.1 and 8.4.2.2 show the results.

At all locations in zone I, especially at the waste treatment station (location 3), and at location 2 in zone II, the γ-background showed increased levels because of the various radiation sources at the research establishment. The weighted annual mean for zones III-V was 6.1 μR/h. In zone I the excess activity from the research establishment was 27.3 - 6.1 = 21.2 μR/h (in 1967: 4.0, in 1968: 3.9, in 1969: 3.3, in 1970: 4.7, in 1971: 1.6, in 1973: 11.5 and in 1974: 16.0 μR/h). A man working in the open in the Risø area 40 hours a week for 45 weeks a year would thus get an excess dose of 38 mR/year.

<u>Table 8.4.2.1</u>

γ-background (μR/h) in Zone I around Risø in 1975

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1	6.9	15.1	7.5	7.2	7.5	6.7	10.5	8.3	7.2	11.8	[illegible]	7.2	8.8
2	9.7	9.9	10.2	10.5	11.3	10.2	10.6	11.8	10.8	10.8	11.0	9.4	10.5
3	66	75	67	67	80	78	58	96	107	79	147	128	87
4	8.6	8.8	9.1	9.1	9.9	7.2	8.8	9.9	9.1	9.4	9.4	8.8	9.0
5	21.4	21.4	19.0	21.1	20.9	20.3	22.8	21.4	20.3	21.4	20.6	17.3	20.6
Mean	22.6	26.2	22.6	23.0	26.0	28.5	22.2	29.4	30.8	26.4	39.6	34.2	27.3

Table 8.4.2.2

γ-background (μR/h) in four zones (II-V) around Risø in 1975

Risø zone *	Location	Mar.	May	July	Sept.	Oct.	Mean
II	1	6.7	6.7	6.9	7.2	7.2	6.9
-	2	7.8	7.8	8.0	8.6	7.8	8.0
-	3	6.1	5.8	5.6	6.7	6.[illegible]	6.1
-	4	7.2	6.9	6.7	7.2	7.2	7.0
Mean		6.9	6.8	6.9	7.4	7.1	7.0
III	1	8.8	8.8	8.6	8.8	8.6	8.7
-	2	7.2	7.2	7.5	8.6	7.2	7.5
-	3	6.9	7.2	7.2	7.5	6.9	7.2
Mean		7.7	7.8	7.8	8.3	7.6	7.8
IV	1		6.7			6.4	6.5
-	2		6.7			7.5	7.1
-	3		6.9			7.5	7.2
-	4		7.2			7.8	7.5
-	5		5.6			6.1	5.8
-	6		6.7			6.4	6.5
-	7		6.7			6.7	6.7
Mean			6.6			6.9	6.8
V	1		6.7			6.1	6.4
-	2		7.2			7.8	7.5
-	3		6.7			6.9	6.8
-	4		6.4			6.1	6.3
-	5		6.9			7.5	7.2
-	6		6.9			7.2	7.1
-	7		6.4			6.9	6.7
-	8		5.6			6.4	6.0
-	9		7.2			7.5	7.4
-	10		6.1			6.1	6.1
Mean			6.6			6.9	6.7

* (cf. coloured map in Risø report no. 323[1])

8.5. Environmental Surveys at Barsebäck and Ringhals

Sweden is operating nuclear power plants facing the Sound at Barsebäck and the Cattegat at Ringhals. Ringhals started up in 1974 and Barsebäck became critical in 1975. As both sites are close to Danish waters and fishing grounds, various marine samples are collected from these areas.

Tables 8.5.1.1 - 8.5.1.2 show the ^{137}Cs levels in 3 cm sections of sediment samples collected in the Sound at Barsebäck in 1975. There was no indication of any contamination from sources other than fall-out. The levels were not significantly higher than the levels measured in 1974[1].

Table 8.5.1.1

Caesium-137 in bed soil collected at Barsebäck in May in 1975

Position	Depth in cm	pCi ^{137}Cs/kg	mCi $^{137}Cs/km^2$
55°44'06"N 12°53'E	0-3	1415	7.52
- " - - " -	3-6	644	7.37
- " - - " -	6-9	412	4.48
- " - - " -	9-12	213	2.43
- " - - " -	15-18	79	1.25
- " - - " -	18-21	B.D.L.	B.D.L.
- " - - " -	21-23	B.D.L.	B.D.L.
	0-23		Σ 23.05
55°59'N 12°42'E	0-3	167	2.54
- " - - " -	3-6	256	5.43
- " - - " -	6-9	142	3.18
- " - - " -	9-12	89 A	2.54 A
- " - - " -	12-15	171	4.31
	0-15		Σ 18.00

Table 8.5.1.2

Caesium-137 in bed soil collected at Barsebäck in December 1975

Position	Depth in cm	pCi ^{137}Cs/kg	mCi $^{137}Cs/km^2$
55°44'06"N 12°53'E	0-3	1029	6.53
- " - - " -	3-6	319	3.19
- " - - " -	6-9	164	1.74
- " - - " -	9-12	147	1.48
	0-12		Σ 12.94
55°43'08"N 12°54'05"E	0-3	817	7.57
- " - - " -	3-6	455	5.86
- " - - " -	6-9	206	2.37
- " - - " -	9-12	94	1.12
	0-12		Σ 16.92
55°44'N 12°56'01"E	0-3	251	3.23
- " - - " -	3-6	163	3.12
- " - - " -	6-9	75	1.62
- " - - " -	9-12	B.D.L.	B.D.L.
	0-12		Σ 7.97

Table 8.5.2 shows the ^{137}Cs levels in sediments collected at Ringhals. Neither was any contamination found here that could not be explained by fall-out.

Table 8.5.3 shows the levels in two sediment samples collected in the Great Belt.

Tables 7.2 and 7.3 give the sea water concentrations of ^{90}Sr and ^{137}Cs at Barsebäck and Ringhals in 1975.

We may conclude that the operation of the nuclear plants at Barsebäck and Ringhals has not so far resulted in measurable contamination of the marine environment by ^{137}Cs, which is one of the most abundant long-lived fission products usually met in liquid effluents from nuclear power stations.

Table 8.5.2

Caesium-137 in bed soil collected at Ringhals in September 1975

Position	Depth in cm	pCi ^{137}Cs/kg	mCi $^{137}Cs/km^2$
57°15'01"N 12°03'07"E	0-3	181	5.13
- " - - " -	3-6	248	8.97
- " - - " -	6-9	92	3.39
- " - - " -	9-10	109	0.55
	0-10		Σ 18.04
57°16'05"N 12°06'E	0-3	42	1.61
- " - - " -	3-6	99	3.66
- " - - " -	6-10	17	0.87
	0-10		Σ 6.14
57°17'01"N 12°07'02"E	0-3	92	2.97
- " - - " -	3-6	56	2.19
- " - - " -	6-9	26	0.99
- " - - " -	9-12	B.D.L.	B.D.L.
	0-12		Σ 6.15
57°13'03"N 12°03'04"E	0-3	119	2.80
- " - - " -	3-6	146	4.26
- " - - " -	6-9	77	2.84
- " - - " -	9-12	128	4.46
	0-12		Σ 14.36

Table 8.5.3

Caesium-137 in bed soil collected in Great Belt in May 1975

Position	Depth in cm	pCi ^{137}Cs/kg	mCi ^{137}Cs/km^2
55°38'N 10°44'E	0-3	405	3.43
- " - - " -	3-6	231	3.93
- " - - " -	6-9	135	1.62
- " - - " -	9-12	70	0.82
- " - - " -	12-15	B.D.L.	B.D.L.
- " - - " -	15-18	B.D.L.	B.D.L.
	0-18		Σ 9.80
55°12'N 11°05'05"E	0-3	176	6.27
- " - - " -	3-6	93	3.12
- " - - " -	6-9	97	3.43
- " - - " -	9-12	16	0.73
	0-12		Σ 13.55

9. CONCLUSION

9.1. Risø Environmental Monitoring

No radioactive contamination of the environment originating from the operation of the research establishment was ascertained outside Risø in 1975. As in previous years, the variations in contamination level were independent of the distance of the sampling locations from Risø.

9.2. Nuclear-Weapon Debris in Air, Precipitation, Soil, Ground Water, and Surface Water

The mean content of ^{90}Sr in air collected in 1975 was 0.9 fCi ^{90}Sr m^{-3}, i.e. 0.6 times the 1974 level. The average fall-out at the State experimental farms in 1975 was 0.41 mCi ^{90}Sr km^{-2} or 0.6 times the 1974 figure, and the mean concentration of ^{90}Sr in rain water was 0.82 pCi ^{90}Sr l^{-1}.

By the end of 1975 the accumulated fall-out down to a depth of 50 cm was approx. 56 mCi ^{90}Sr km^{-2}. The corresponding ^{137}Cs was measured at 9[illegible] mCi km^{-2}.

In agreement with the greater precipitation in that part of the country, fall-out levels in Jutland were 15-25% higher than levels found in eastern Denmark.

The median level of ^{90}Sr in Danish ground water was 17 fCi $^{90}Sr\ l^{-1}$.

9.3. Strontium-90 and Caesium-137 in the Human Diet

The mean level of ^{90}Sr in Danish milk was 4.1 S.U., and the mean content of ^{137}Cs was approx. 3.7 pCi $^{137}Cs\ l^{-1}$.

The 1975 ^{90}Sr levels were a little lower than the levels found in milk produced in 1974, while the ^{137}Cs levels had decreased markedly.

The ^{90}Sr mean content in grain from the 1975 harvest was 22 pCi $^{90}Sr\ kg^{-1}$. The ^{137}Cs mean content in grain was 13 pCi $^{137}Cs\ kg^{-1}$. The ^{90}Sr level in grain from the 1975 harvest was 0.7 times the level found in the 1974 harvest, and ^{137}Cs was 0.3 times the 1974 level.

The mean contents of ^{90}Sr and ^{137}Cs in Danish vegetables collected in 1975 were 11 pCi $^{90}Sr\ kg^{-1}$ (29 S.U.) and 3 pCi $^{137}Cs\ kg^{-1}$ respectively, and in fruits 1.7 pCi $^{90}Sr\ kg^{-1}$ and 2.1 pCi $^{137}Cs\ kg^{-1}$; potatoes contained 3.7 pCi $^{90}Sr\ kg^{-1}$ and 7 pCi $^{137}Cs\ kg^{-1}$.

The mean levels of ^{90}Sr and ^{137}Cs in total-diet samples collected in 1975 were 6.4 S.U., or 11 pCi $^{90}Sr\ day^{-1}$ and 18 pCi $^{137}Cs\ day^{-1}$ respectively. From analyses of the individual diet components, the ^{90}Sr level in the Danish average diet was estimated to be 5.5 S.U. and the ^{137}Cs intake to be 17 pCi $^{137}Cs\ day^{-1}$. The ^{137}Cs levels in the Danish total diet consumed in 1975 were nearly equal to the 1974 levels while the ^{90}Sr levels probably were lower.

Grain products contributed 35% and milk products 33% to the total ^{90}Sr intake; 25% of the ^{137}Cs in the diet originated from meat, 31% from grain products, and 16% from milk products.

Both ^{90}Sr and ^{137}Cs diet levels were on the average significantly higher in Jutland than in eastern Denmark.

9.4. Strontium-90 and Caesium-137 in Humans

The ^{90}Sr mean content in human bone (vertebrae) collected in 1975 was 1.3 S.U. in new-born children, 2.0 S.U. in infants, 1.5 S.U. in children and teenagers, 1.4 S.U. in adults (20-29 years old), and 1.5 S.U. in adults of more than 29 years. The 1975 bone levels were generally a little higher than the 1974 levels.

The mean content of ^{137}Cs in the human body in 1975 was estimated from whole-body countings to be 1.6 nCi (11 pCi $^{137}Cs/g\ K$), i.e. nearly equal to the 1974 level.

9.5. Strontium-90 in Sea Water

The mean content of ^{90}Sr in inner Danish surface waters was approx. 0.70 pCi $^{90}Sr\ l^{-1}$ in 1975, i.e. lower than the level in 1974. The ^{137}Cs mean level in Danish surface waters in 1975 was 0.75 pCi l^{-1}, i.e. equal to the 1974 concentration.

9.6. The γ-Background

The average γ-background measured with a NaI crystal at the State experimental farms in 1975 was 6.3 μR/h.

9.7. Caesium-137 in the Marine Environment at Barsebäck and Ringhals

Samples of sediments and sea water collected at Barsebäck and Ringhals in 1975 did not show any indication of increased ^{137}Cs levels due to the operation of the nuclear power plants at the two sites.

9.8. Summary

The concentrations of long-lived fall-out nuclides in ground-level air and precipitation collected in 1975 were 0.6 times the levels found in 1974.

In milk produced in 1975 the ^{137}Cs levels were 0.5 times the 1974 levels. In grain from 1975 the ^{137}Cs levels were 0.3 times those found in 1974.

The ^{90}Sr and ^{137}Cs levels in the total diet consumed in 1975 were a little lower of nearly unchanged respectively as compared with the 1974 levels.

The ^{90}Sr concentrations in human bone were a little higher in 1975 than in 1974.

APPENDIX A

Calculated Fall-out in the Eight Zones in 1975

Zone	mm precipitation in 1975	mCi $^{90}Sr/km^2$ in 1975	Accumulated mCi $^{90}Sr/km^2$ by the end of 1975(0-50 cm)
I: N. Jutland II: E. Jutland III: W. Jutland IV: S. Jutland	562	0.471	67
V: Funen VI: Zealand VII: Lolland-Falster	444	0.346	48
VIII: Bornholm	452	0.493	61
Area-weighted mean	539	0.442	61

The amounts of precipitation were obtained from ref. 9, and from 4.1 and 4.2.

APPENDIX B

Statistical information

Zone		Area in km² 15) 1971	Population in thousands 15) 1971	Annual milk production in mega-kg 14) 1971	Annual wheat production in mega-kg 13) 1972	Annual rye production in mega-kg 13) 1972	Annual potato production in mega-kg 13) 1972	Vegetable area in km² 13) 1972
I:	N. Jutland	6,171	457	911	145	155	609	14
II:	E. Jutland	7,561	841	1,258				
III:	W. Jutland	12,104	661	926				
IV:	S. Jutland	3,929	239	572				
V:	Funen	3,486	434	393				
VI:	Zealand	7,435	2,146*	395	448	71	100	73
VII:	Lolland-Falster	1,795	125	68				
VIII:	Bornholm	588	47	39				
Total		43,069	4,950	4,562	593	226	709	87

* 1,345,000 people were living in Greater Copenhagen and 801,000 in the remaining part of Zealand.

APPENDIX C

We have in 1974 revised our prediction models for diet components and total diet. For milk we used our data[1] from 1962-75, for grain: 1959-74 (^{137}Cs: 1962-74), and for total diet: 1961-74. The terms in the models were similar to those used in previous years (cf. Risø Report No. 305, Appendix C[1]), but for ^{90}Sr we divided the term for accumulated fall-out (A_i) into two terms, one with an effective half-life of ^{90}Sr of 5 years and one with a 28-year half-life.

This has in general improved the models. In a few cases, however, one of the two A_i terms became negative. The model was then altered to one A_i term and tested for half-lives of 5, 10, 15, 20, 25 and 28 years. We then chose the half-life giving the best fit.

In Appendix D values are shown for the ^{90}Sr fall-out rates (d_i) and the accumulated ^{90}Sr fall-out (A_i) used in our calculations of prediction models.

In tables C1 and C2 we have also calculated the infinite exposure integral (IEI) for the diet components and the total diet. IEI is equal to the equilibrium level in the diet for a constant annual fall-out rate of 1 mCi ^{90}Sr/km^2, or to the UNSCEAR[21] transfer coefficient P_{23}. In the case of ^{137}Cs the prediction models are given for d_i and A_i values of ^{90}Sr as also the IEI values.

It is remarkable that, with the exception of ^{90}Sr in potatoes and total diet, Jutland in all cases shows higher IEI values than the Islands. The reason why the total diet differs from the general pattern is probably due to a transfer of foods (e.g. milk) from Jutland to the Islands in recent years. This has made the total diet levels in the Islands decrease more slowly than the levels in Jutland. This again has resulted in an overestimation of the coefficients for the A_i terms in the prediction model for the Islands.

Table C 1

A comparison between observed and predicted ^{90}Sr levels in the human food chain in Denmark in 1975

Sample and area	Observed	Predicted	Equation used for the prediction	I.E.I.
Grass from Zealand	44	36	$S.U_i = 28.1\ d_i + 9.23\ d_{i-1} + 1.34\ A_{i-2(5)}$	47.0
Milk from Jutland	4.9	5.1	$S.U_i = 1.00\ d_i + 0.721\ d_{i-1} + 0.222\ A_{i-2(5)}$	3.3
Milk from the Islands	3.0	[illegible]	$S.U_i = 0.746\ d_i + 0.665\ d_{i-1} + 0.128\ A_{i-2(5)} + 0.0148\ A_{i-2(27.7)}$	2.9
Rye from Jutland	87	[illegible]	$S.U_i = 222\ d_{i(\text{July-Aug.})} + 0.147\ A_{i-1(5)} + 0.788\ A_{i-1(27.7)}$	69.6
Rye from the Islands	25	37	$S.U_i = 170\ d_{i(\text{July-Aug.})} + 0.57\ A_{i-1(27.7)}$	51.1
Barley from Jutland	61	55	$S.U_i = 164\ d_{i(\text{July-Aug.})} + 1.78\ A_{i-1(5)} + 0.167\ A_{i-1(27.7)}$	46.9
Barley from the Islands	26	25	$S.U_i = 98\ d_{i(\text{July-Aug.})} + 0.83\ A_{i-1(5)} + 0.180\ A_{i-1(27.7)}$	29.5
Wheat from Jutland	72	77	$S.U_i = 164\ d_{i(\text{July-Aug.})} + 1.74\ A_{i-1(5)} + 0.55\ A_{i-1(27.7)}$	61.9
Wheat from the Islands	36	41	$S.U_i = 138\ d_{i(\text{July-Aug.})} + 0.44\ A_{i-1(5)} + 0.56\ A_{i-1(27.7)}$	48.6
Oats from Jutland	51	61	$S.U_i = 73.7\ d_{i(\text{July-Aug.})} + 0.91\ A_{i-1(27.7)}$	48.7
Oats from the Islands	21	28	$S.U_i = 59.5\ d_{i(\text{July-Aug.})} + 0.50\ A_{i-1(27.7)}$	29.9
Potatoes from Jutland	3.9	3.6	$\text{pCi}\ {}^{90}Sr\ kg^{-1} = 0.120\ d_i + 0.101\ d_{i-1} + 0.056\ A_{i-2(27.7)}$	2.5
Potatoes from the Islands	3.4	3.1	$\text{pCi}\ {}^{90}Sr\ kg^{-1} = 0.159\ d_i + 0.076\ d_{i-1} + 0.061\ A_{i-2(27.7)}$	2.7
White Cabbage from Jutland	15.5	11.5	$\text{pCi}\ {}^{90}Sr\ kg^{-1} = 0.241\ d_i + 0.72\ d_{i-1} + 0.178\ A_{i-2(27.7)}$	8.1
White Cabbage from the Islands	11.0	8.6	$\text{pCi}\ {}^{90}Sr\ kg^{-1} = 0.584\ d_i + 0.034\ d_{i-1} + 0.090\ A_{i-2(5)} + 0.147\ A_{i-2(27.7)}$	7.1
Carrots from Jutland	18.6	18.5	$\text{pCi}\ {}^{90}Sr\ kg^{-1} = 0.592\ d_i + 0.186\ A_{i-1(5)} + 0.253\ A_{i-1(27.7)}$	12.0
Carrots from the Islands	7.1	9.4	$\text{pCi}\ {}^{90}Sr\ kg^{-1} = 0.408\ d_i + 0.225\ A_{i-1(5)} + 0.131\ A_{i-1(27.7)}$	7.3
Total diet from Jutland	6.0	6.8	$S.U_i = 1.49\ d_i + 0.95\ d_{i-1} + 0.097\ A_{i-2(5)} + 0.061\ A_{i-2(27.7)}$	5.6
Total diet from the Islands	5.9	5.9	$S.U_i = 1.39\ d_i + 0.98\ d_{i-1} + 0.0114\ A_{i-2(5)} + 0.094\ A_{i-2(27.7)}$	6.2
Newborns' bone from Denmark	1.3	1.3	$S.U_i = 0.073\ d_i + 0.142\ d_{i-1} + 0.0218\ A_{i-2(27.7)}$	1.1
Human bone > 29 years from Denmark	1.5	1.3	$S.U_i = 0.067\ d_{\frac{(i)+(i-1)}{2}} + 0.036\ A_{i-2(5)} + 0.0121\ A_{i-2(27.7)}$	0.8

Table C 2

A comparison between observed and predicted ^{137}Cs levels in the human food chain in Denmark in 1975

Sample and area	Observed	Predicted	Equation used for the prediction	T.E.I.
Milk from Jutland	4.8	5.6	$M.U_i = 4.36\ d_i + 1.55\ d_{i-1} + 0.245\ d_{i-2} + 0.0379\ A_{i-3(30)}$	7.8
Milk from the Islands	2.2	3.0	$M.U_i = 2.58\ d_i + 1.53\ d_{i-1} + 0.0215\ A_{i-2(30)}$	5.0
Rye from Jutland	23	23	$pCi\ ^{137}Cs\ kg^{-1} = 131\ d_{i(May-Aug.)}$	43.7
Rye from the Islands	11.3	17.7	$pCi\ ^{137}Cs\ kg^{-1} = 125\ d_{i(May-Aug.)}$	41.7
Barley from Jutland	10.1	18.0	$pCi\ ^{137}Cs\ kg^{-1} = 101\ d_{i(May-Aug.)}$	33.7
Barley from the Islands	6.3	11.8	$pCi\ ^{137}Cs\ kg^{-1} = 84\ d_{i(May-Aug.)}$	28.0
Wheat from Jutland	11.9	20.3	$pCi\ ^{137}Cs\ kg^{-1} = 113\ d_{i(May-Aug.)}$	37.7
Wheat from the Islands	7.6	10.1	$pCi\ ^{137}Cs\ kg^{-1} = 72\ d_{i(May-Aug.)}$	24.0
Oats from Jutland	23	14.8	$pCi\ ^{137}Cs\ kg^{-1} = 83\ d_{i(May-Aug.)}$	27.7
Oats from the Islands	9.5	11.0	$pCi\ ^{137}Cs\ kg^{-1} = 78\ d_{i(May-Aug.)}$	26.0
Potatoes from Jutland	7.8	6.1	$pCi\ ^{137}Cs\ kg^{-1} = 5.33\ d_i + 0.061\ A_{i-1(30)}$	8.0
Potatoes from the Islands	5.5	2.0	$pCi\ ^{137}Cs\ kg^{-1} = 5.34\ d_i$	5.3
White cabbage from Denmark	3.5	3.5	$pCi\ ^{137}Cs\ kg^{-1} = 0.322\ d_{(i)+(i-1)} + 0.057\ A_{i-2(30)}$	3.1
Carrots from Denmark	2.0	2.0	$pCi\ ^{137}Cs\ kg^{-1} = 2.36\ d_i + 0.128\ d_{(i-1)+(i-2)} + 0.016\ A_{i-3(30)}$	3.3
Total diet from Jutland	3.7	3.3	$M.U_i = 3.79\ d_i + 1.58\ d_{(i-1)+(i-2)}$	7.0
Total diet from the Islands	3.8	2.5	$M.U_i = 3.49\ d_i + 1.48\ d_{(i-1)+(i-2)}$	6.5
Pork from Denmark	32	28	$pCi\ ^{137}Cs\ kg^{-1} = 41.2\ d_i + 14.39\ d_{i-1} + 5.66\ d_{i-2}$	61.3
Beef from Denmark	22	25	$pCi\ ^{137}Cs\ kg^{-1} = 37.8\ d_i + 2.26\ d_{(i-1)+(i-2)} + 0.130\ A_{i-3(30)}$	48.0
Wholebody from the Islands	11.3	14.6	$M.U_i = 3.83\ d_i + 6.74\ d_{(i-1)+(i-2)} + 0.154\ A_{i-3(30)}$	24.0

APPENDIX D

d_i: Annual fall-out rate in mCi $^{90}Sr\ km^{-2}y^{-1}$.

$A_{i(5)}$: Accumulated fall-out by the end of the year (i) assuming an effective half-life of ^{90}Sr of 5 y.
Unit: mCi $^{90}Sr\ km^{-2}$.

$A_{i(15)}$ and $A_{i(27.7)}$:

Accumulated fall-out by the end of the year (i) assuming effective half-lives of ^{90}Sr of 15 y and 27.7 y respectively.
Unit: mCi $^{90}Sr\ km^{-2}$.

$d_{i(May-Aug.)}$ and $d_{i(July-Aug.)}$:

The fall-out rates in the periods:
May-Aug. and July-Aug. respectively.
Unit: mCi $^{90}Sr\ km^{-2}\ period^{-1}$.

The fall-out rate (d_i) was based on the Danish country wide collected precipitation data for the period 1962-1974 (cf. table 4.11[1]). Before 1962 the levels in the tables have been estimated from the HASL data for New York (HASL Appendix 291, 1975) considering that the mean ratio between ^{90}Sr fall-out in Denmark and New York has been 0.7 in the period 1962-1974.

The $d_{i(May-Aug.)}$ and $d_{i(July-Aug.)}$ values were also obtained from table 4.1.![1] for the period 1962-1974. For the years 1959-1961 the values were calculated from data obtained from ^{90}Sr analysis on air (1959) and precipitation samples (1962 and 1961) collected at Risø (cf. ref. 17) and before 1959 the values were estimated from the corresponding d_i values assuming that the ratios $d_{i(May-Aug.)}/d_i$ and $d_{i(July-Aug.)}/d_i$ were constant in time and equal to the means found for the period 1962-1974 which were 0.54 (1 S.D.: 0.09) and 0.24 (1 S.D.: 0.06) respectively.

APPENDIX D

Fallout rates and accumulated fallout (mCi $^{90}Sr/km^2$) in Denmark 1950-1975

	Denmark				Jutland				Islands				Denmark		Jutland		Islands	
	d_i	$A_{i(5)}$	$A_{i(15)}$	$A_{i(27.7)}$	d_i	$A_{i(5)}$	$A_{i(15)}$	$A_{i(27.7)}$	d_i	$A_{i(5)}$	$A_{i(15)}$	$A_{i(27.7)}$	$d_{i(May-Aug.)}$	$d_{i(July-Aug.)}$	$d_{i(May-Aug.)}$	$d_{i(July-Aug.)}$	$d_{i(May-Aug.)}$	$d_{i(July-Aug.)}$
1950	0,021	0,018	0,020	0,020	0,022	0,019	0,021	0,021	0,020	0,017	0,019	0,020	0,01	0,01	0,01	0,01	0,01	0,01
1951	0,101	0,104	0,116	0,118	0,114	0,116	0,129	0,132	0,088	0,092	0,102	0,105	0,05	0,02	0,06	0,03	0,05	0,02
1952	0,198	0,263	0,299	0,309	0,224	0,296	0,337	0,347	0,172	0,230	0,262	0,270	0,11	0,05	0,12	0,05	0,09	0,04
1953	0,500	0,664	0,763	0,789	0,566	0,751	0,867	0,891	0,434	0,578	0,665	0,687	0,27	0,12	0,31	0,14	0,23	0,10
1954	1,901	2,213	2,544	2,623	2,152	2,526	2,878	2,967	1,650	1,919	2,210	2,279	1,01	0,40	1,14	0,52	0,89	0,40
1955	2,501	4,121	4,817	4,997	2,821	4,666	5,451	5,655	2,171	3,578	4,183	4,340	1,35	0,60	1,51	0,68	1,17	0,52
1956	3,101	6,28[illegible]	7,560	7,898	3,510	7,116	8,557	8,939	2,692	5,458	6,564	6,858	1,67	0,74	1,90	0,84	1,45	0,65
1957	3,101	8,173	10,180	10,728	3,510	9,251	11,522	12,142	2,692	7,095	8,838	9,313	1,67	0,74	1,90	0,84	1,45	0,65
1958	4,302	10,860	13,828	14,658	4,869	12,292	15,651	16,591	3,734	9,427	12,004	12,725	2,32	1,03	2,61	1,17	2,02	0,90
1959	6,102	14,766	19,030	20,247	6,908	16,715	21,540	22,918	5,297	12,817	16,519	17,576	2,50	0,68	2,76	0,75	2,24	0,61
1960	1,140	13,847	19,259	20,859	1,291	15,675	21,800	23,610	0,990	12,020	16,713	18,107	0,47	0,31	0,52	0,34	0,42	0,28
1961	1,481	13,364	19,803	21,767	1,676	15,105	22,416	24,641	1,285	11,583	17,190	18,913	0,66	0,47	0,73	0,52	0,59	0,42
1962	7,428	18,083	26,001	28,493	7,976	20,093	29,019	31,830	6,880	16,073	23,983	25,155	4,223	1,857	4,566	2,052	3,880	1,663
1963	16,695	30,276	40,768	44,071	18,453	33,556	45,329	49,041	14,937	26,996	36,208	39,101	9,965	5,629	10,753	5,932	9,177	5,327
1964	10,412	35,421	48,869	53,136	11,68[illegible]	39,384	54,439	59,225	9,139	31,457	43,209	47,068	6,235	2,560	7,170	2,910	5,349	2,226
1965	3,954	34,277	50,437	55,679	4,[illegible]	37,966	55,994	61,861	3,704	30,609	44,888	49,477	2,029	0,850	2,094	0,852	1,464	0,848
1966	2,145	31,707	50,207	56,395	2,168	34,919	55,534	62,445	2,124	28,695	44,881	50,345	1,049	0,418	0,884	0,496	1,114	0,340
1967	1,047	28,514	48,940	56,023	1,176	31,423	54,149	62,048	0,918	25,606	43,731	49,997	0,367	0,141	0,380	0,13[illegible]	0,354	0,148
1968	1,403	26,064	48,089	56,006	1,568	28,720	53,201	62,045	1,237	23,368	42,938	49,960	0,848	0,420	0,910	0,460	0,786	0,392
1969	1,035	23,574	46,887	55,632	1,241	26,083	51,983	61,721	0,839	21,065	41,791	49,563	0,614	0,276	0,723	0,319	0,505	0,231
1970	1,647	21,956	46,342	55,863	1,993	24,442	51,539	62,140	1,301	19,471	41,146	49,586	0,908	0,547	1,076	0,632	0,740	0,462
1971	1,506	20,425	45,600	55,951	1,726	22,780	50,860	62,280	1,284	18,070	40,515	49,618	0,992	0,405	1,154	0,516	0,830	0,396
1972	0,435	18,160	44,040	54,993	0,457	20,329	49,080	61,194	0,413	16,090	39,08[illegible]	48,792	0,253	0,086	0,262	0,084	0,246	0,084
1973	0,192	15,976	42,235	53,831	0,215	19,569	46,993	59,891	0,168	14,153	37,476	47,750	0,075	0,033	0,093	0,039	0,057	0,027
1974	0,710	14,520	41,004	53,183	0,779	17,697	45,615	59,171	0,643	12,881	36,398	47,197	0,421	0,190	0,463	0,219	0,378	0,162
1975	0,414	13,006	39,550	52,272	0,452	15,800	4[illegible],987	58,150	0,376	11,541	35,113	46,397	0,159	0,075	0,179	0,091	0,141	0,068

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